

AIHA Virtual Seminar, Exposure Assessment Strategies

Statistical Methods Review



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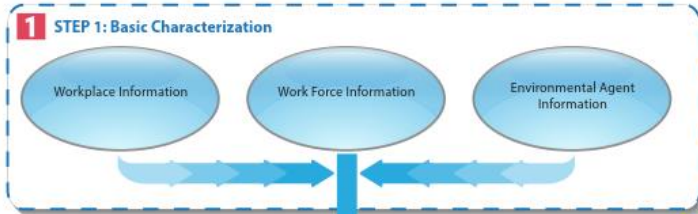
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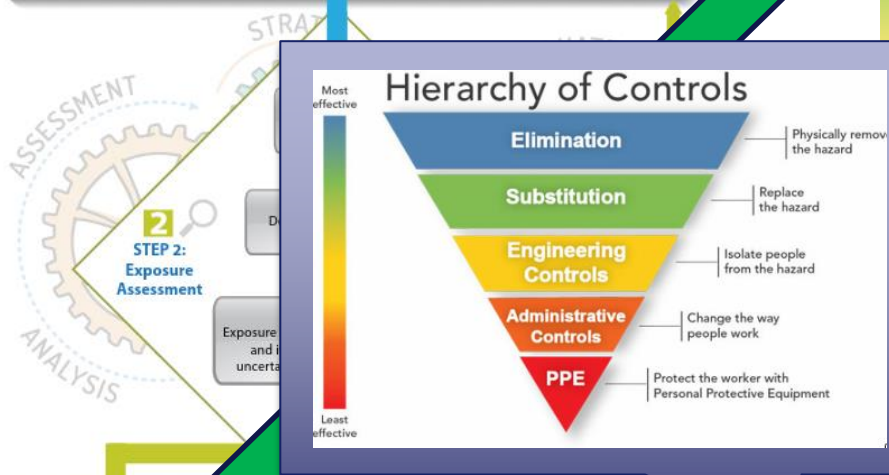
CONTENTS OVERVIEW

- Survey design implications and decision rules impact
- Rules of thumb for low n data sets
- Descriptive, inferential, and Bayesian approaches
- Introduction to several tools for data analysis
 - IH Stat – descriptive and inferential statistics
 - Two Bayesian tools - descriptive and inferential statistics with Bayesian methods
 - IHDA – Student version
 - EXPOSTATS

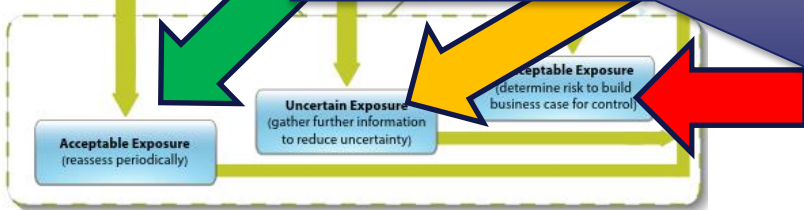
WHAT DECISIONS MIGHT YOU MAKE WITH SURVEY DATA?



Great! But, is it a TRUE finding?
False **NEGATIVES** can be **DANGEROUS!**
What should you do?
Confirm with more data?
Apply statistics?



Hmm! A common finding!
What do you do? Get more data?
Apply statistics? Control?



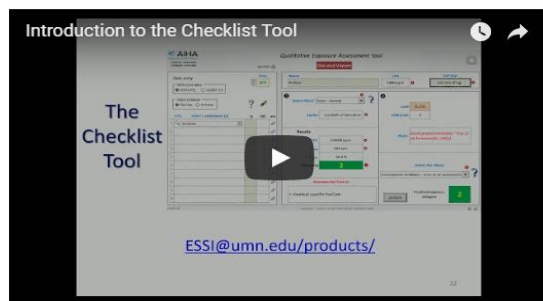
Oh, NO! Is it REALLY true? What do we do?
Get more data?
Apply Statistics?
Apply interim or final controls?

QUALITATIVE (I.E., PROFESSIONAL JUDGEMENT DECISIONS)

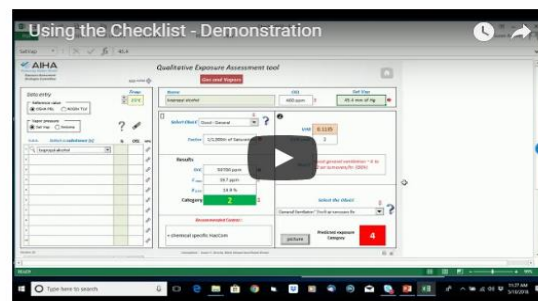
- Most exposure assessment decisions are with $n=0$
- Without specific training and use of “rules of thumb” almost 2/3 of judgements with $n=0$ may be WRONG and usually LOW.
- With data and statistical tools, the decisions may improve
- We will not cover the “rules of thumb” for $n=0$ here since we are addressing STATISTICS and $n=1$ or more

Check at <http://essi.umn.edu/> tab RESOURCES, then PRODUCTS for
More about an IH Qualitative Exposure Assessment Tool – Checklist

INTRODUCTION TO THE CHECKLIST TOOL



USING THE CHECKLIST - DEMONSTRATION



FIRST, A BIT ABOUT DATA QUALITY FOR STATISTICS

- Do you actually have relevant data?
- Are the data from a stationary population?
- Are the samples from a mostly random or stratified mostly random survey strategy?
- How good is your Similar Exposure Group (SEG) formation process?
 - SWAG from an office?
 - Walkthrough survey?
 - Walkthrough And discussions with workers?
 - If reasonably good, statistical methods we will discuss can help show if it is reasonably an SEG

Let's take a look

Adapted from BSSim by Paul Hewett (explained in more detail in the software:<https://www.easinc.co/>)

Example Survey Strategies and Decision

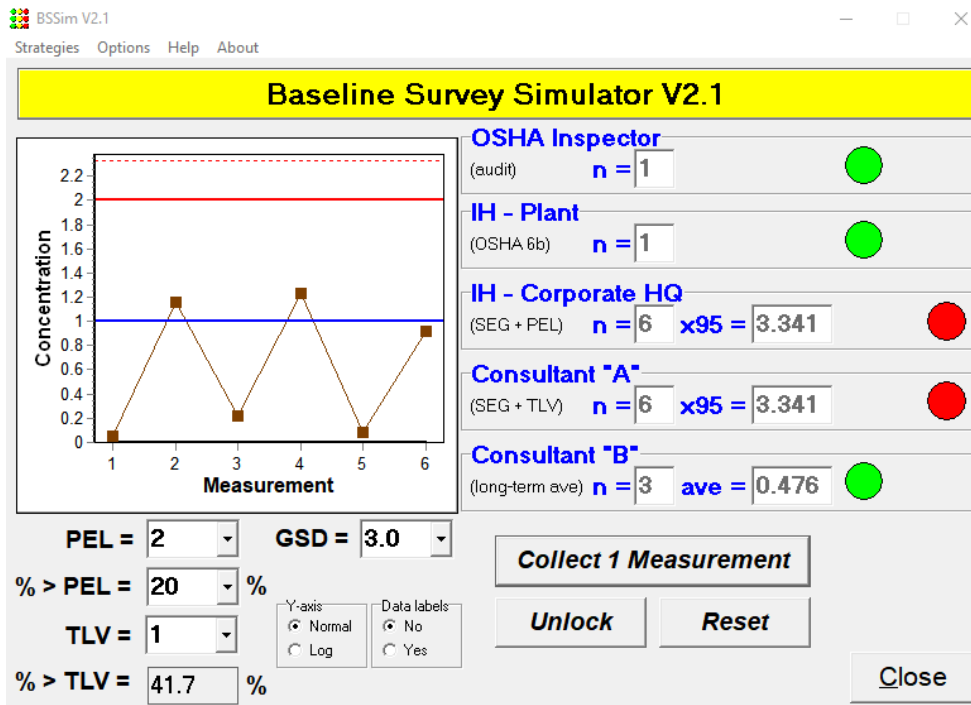
- An OSHA inspector, who considers acceptable any single measurement that is equal to or less than the PEL [Can be one sample from one day]
- A plant IH who recommends the least complicated strategy permitted by the OSHA 6b (single substance) regulations. [If the initial C is < Action Limit (AL), then the work environment appears acceptable, If $AL \leq C \leq PEL$, then collect additional measurements until 2 consecutive measurements are < AL, or any $C > PEL$]
- A corporate IH who follows that the AIHA exposure assessment model with the OSHA PEL with a minimum of six samples [Estimate the SEG upper percentile (e.g., 95th percentile)]
- Consultant A)uses the AIHA model, but with the lower TLV® with a minimum of six samples
- Consultant B believes that nearly all 8-hour TWA OELs can be interpreted as the upper limit for a worker's long-term, lifetime average exposure. Single overexposures are unimportant and with a minimum of three samples

HOW MIGHT A SURVEY STRATEGY IMPACT OUR DECISIONS?

Illustration of a “What if” approach Using *Baseline Survey Simulator*

Thanks to Paul Hewett, <https://www.easinc.co>

I set the “conditions” of the PEL and the 20% over the PEL. 20%!!



What if ... we survey a number of times, say 10 for the indicated number of samples (n)

- What might we conclude for n=1?
- OSHA OK for 9 out of 10 runs at n=1!
- Plant IH Also OK for 9 out of 10 at n=1!

And then, for n=6, ONE RUN!

- OSHA OK, Plant IH OK
- Corporate IH PROBLEM!
- Consultant A PROBLEM!
- Consultant B OK!

If you try this, due to random samples, your results may be strikingly different. At n=1 you MIGHT get a > PEL sample. In 9 out of ten tries I did not.

Run Baseline Strategy Simulator

AIHA EXPOSURE AND RISK MATRIX

SEG Exposure Risk Rating	95th Percentile Relative to OEL
0	<1% of OEL (95th percentile less than 0.01 x OEL)
1	<10% of OEL (95th percentile less than 0.1 x OEL)
2	10-50% of OEL (95th percentile between 0.1 x OEL and 0.5 x OEL)
3	50-100% of OEL (95th percentile between 0.5 x OEL and 1.0 x OEL)
4	>100% of OEL (95th percentile greater than 1.0 x OEL)

Health Risk Ranking (Assessment)						
Exposure Rating Categorization (Probability)	4					Very High
	3				High Cr+3	
	2			Moderate		Cr+6
	1		Low			
	0	Trivial				
	0	1	2	3	4	
Health Effects Rating Categorization (Consequence)						

How good is the OEL?
 Dated OSHA PEL?
 ACGIH TLV? Under review?
 Other?
 Well documented?

How “severe” is the adverse effect?

Quick Rule of Thumb Decision Rules

(Assuming log-normally distributed DATA)

1. $\hat{X}_{95\%} = GM \times GSD^{1.645}$
2. Low n, ANY value > OEL = problem
3. Estimate the median value (about the middle of the range) and use a multiplier
2X if low spread,
4X if moderate spread,
6X if large spread

Est'd GSD	Multiplier
1.5	1.95
2.0	3.13
2.5	4.51
3.0	6.09

Variability and Multiplier

Low 2

Medium 4

High 6

What Can We Decide? **OEL = 2.** These are from a randomly generated distribution with parameters set by me for this exercise

- Survey 1, value 0.22
- Survey 2, values 0.65, 0.92
- Survey 3, values 0.87, 0.23, 1.75
- Survey 4, values 0.12, 1.31, 0.34, 1.54
- Survey 5, values 0.07, 0.83, 0.14, 0.48, 0.10
- Survey 6, values 2.93, 0.23, 0.18, 0.74, 0.44, 1.98

SEG Exposure Risk Rating	95th Percentile Relative to OEL
0	<1% of OEL (95th percentile less than 0.01 x OEL)
1	<10% of OEL (95th percentile less than 0.1 x OEL)
2	10-50% of OEL (95th percentile between 0.1 x OEL and 0.5 x OEL)
3	50-100% of OEL (95th percentile between 0.5 x OEL and 1.0 x OEL)
4	>100% of OEL (95th percentile greater than 1.0 x OEL)

Variability & Multiplier

Low 2, Medium 4, High 6

I specified the distribution as: “True” AM = 1.8 with GM 1.0, GSD 3. For n=100, UCL95% on AM = 2.3, LTL on AM = 1.5, 95th %ile of the distribution is approximately 3.6. The OEL Exceedance Fraction is about 17%.

Descriptive statistics deal with the data you have

- Number of samples
- Maximum value
- Minimum value
- Percent of measurements above the OEL
- Mean value
- Standard deviation of the data
- Mean of log-transformed data
- Standard deviation of the log-transformed data
- Geometric mean
- Geometric standard deviation

With low n, you really do not know much and cannot infer with confidence

INFERENTIAL STATISTICS....

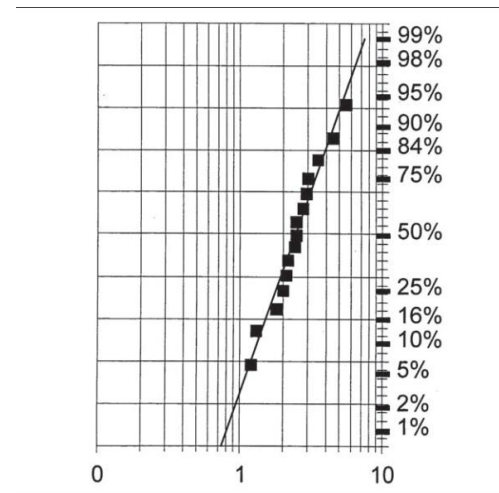
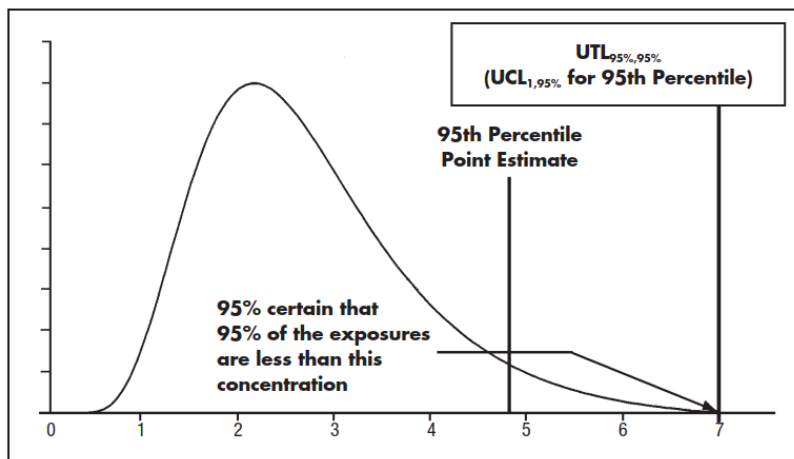
Make predictions about the POPULATION of exposures from the SAMPLED exposures.

Mean exposure and its confidence interval

95th percentile exposure and the confidence interval on that value

Exceedance fraction, more

Low n, wide confidence intervals



Logprobability plots can tell you a lot about the data set

DID YOU REMEMBER TO BRING A CALCULATOR?

Let's check if you remember how to calculate the GM, GSD, exceedance fraction for a presumed lognormal data set of $n=10$.

Here are the numbers.

0.98, 0.87, 3.01, 2.50, 2.65,

1.26, 6.76, 3.59, 0.41, 0.34

You may begin!

JUST KIDDING!

We have great software tools to do the heavy lifting!

Now we will show a few of the tools and their utility!

Give thanks to the developers...

Isn't this slick?! This is the n=6 data

Industrial Hygiene Statistics

OEL
2

Sample data

2.93
0.23
0.18
0.74
0.44
1.98

Descriptive statistics

Number of samples (n)	6
Maximum (max)	2.93
Minimum (min)	0.18
Range	2.75
Mean	1.08
Median	0.59
Standard deviation (s)	1.12
Geometric mean	0.654
Geometric standard deviation	3.10
Percent above OEL	16.7%

Test for distribution fit

W-test of log-transformed data
Lognormal ($\alpha = 0.05$)? **Yes**

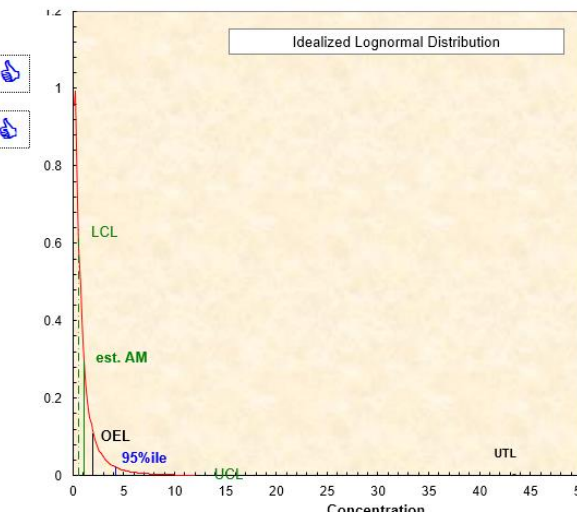
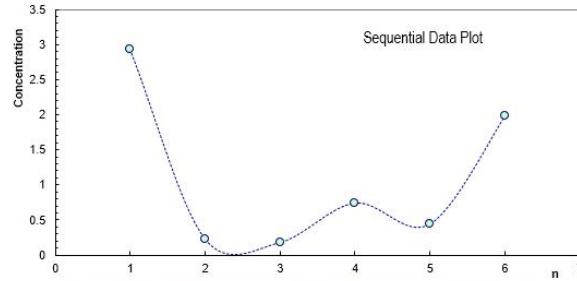
W-test of data
Normal ($\alpha = 0.05$)? **Yes**

Lognormal parametric statistics

Estimated Arithmetic Mean - AM est	1.080
LCL1,95% - Land's "Exact"	0.550
UCL1,95% - Land's "Exact"	12.600
95th Percentile	4.208
UTL95%, 95%	43.4
Percent above OEL	16.2%
LCL1,95% %>OEL	3.7
UCL1,95% %>OEL	45.5

Normal parametric statistics

Mean	1.08
LCL1,95% - t statistics	0.161
UCL1,95% - t statistics	2.006
95th Percentile - Z	2.928
UTL95%, 95%	5.23
Percent above OEL	20.6%



Let's take a look at the $n=5$ data values
0.07, 0.83, 0.14, 0.48, 0.10

Run IH Stat

HERE ARE THE N=6 DATA

.... with a Bayesian Tool, IHDA Student Version
 (Thanks to Paul Hewett, <https://www.easinc.co/ihda-student/>)
 The design is set to give CATEGORICAL probabilities

Calculate All | GOF Graphs | Statistics | BDA Charts

Data | GOF | BDA Initial Rating | CDA

Facility Information
 Facility: TWA Test
 Department: _____
 Building: _____
 Process: _____
 Task: _____

Substance Information
 Substance: Hypothetical One
 OEL: 2 ppm

Comments

Case	Day	Conc	<LOD	DATE	GROUP
1	Day 6	2.93			
2	Day 6	0.23			
3	Day 6	0.18			
4	Day 6	0.74			
5	Day 6	0.44			
6	Day 6	1.98			
7					
8					
9					
10					
11					
12					
13					
14					

Goodness-of-fit Tests:
 Fillibens Test:
 R = 0.977
 critical R = 0.889
 Interpretation: the lognormal distribution hypothesis is not rejected.

OEL = 2 ppm

Order Statistics:
 N = 6
 Min = 0.18
 Max = 2.93
 Median = 0.5900

Descriptive Statistics:
 Mean = 1.0800
 SD = 1.1200
 GM = 0.6540
 GSD = 3.1000

Compliance Statistics (lognormal):
 X0.95 = 4.2100 95%LCL = 1.7600 95%UCL = 43.5000
 ExcFrac = 0.162 95%LCL = 0.037 95%UCL = 0.455

Bayesian Decision Charts:
 Type of prior decision distribution:
 Uniform prior

Rating: 0-T 1-HC 2-WC 3-C 4-PC
 Cutoff (%OEL): 1.0 10.0 50.0 100.0 >100.0

Prior 0.200 0.200 0.200 0.200 0.200
 Likelihood 0.000 0.000 0.001 0.104 0.895
 Posterior 0.000 0.000 0.001 0.104 0.895

Cum Likelihood 0.000 0.000 0.001 0.105 1.000
 Cum Posterior 0.000 0.000 0.001 0.105 1.000

Parameter space: GMmin = 0.000408951 GMmax = 10
 GSDmin = 1.05 GSDmax = 4

IHDataAnalyst-Student 2018b

File | View | Calculate | Graphs | Options | Help

Calculate All | GOF Graphs | Statistics | BDA Charts

Data | GOF | BDA Initial Rating | CDA

Statistics | GOF Graphs | BDA Charts | CDA

Categorical

Prior Decision Distribution
 Generic Professional Judgment Prior
 Custom Professional Judgment Prior
 Uniform Prior

Professional Judgment
 Initial Rating: 3 - Controlled
 Certainty Level: 2 - Medium

Rating	Probability
0 - Trivial	0.03
1 - Highly-controlled	0.06
2 - Well-controlled	0.16
3 - Controlled	0.5
4 - Poorly-controlled	0.25

Sum = _____
 Post Changes | Cancel Changes

Prior Decision Distribution

Decision Probability vs Exposure Rating (Prior):
 0: 0.03, 1: 0.06, 2: 0.16, 3: 0.5, 4: 0.25

Charts

Bars and Labels
 Solid bars
 Solid bars with labels
 Colored bars

Select Final Rating and Certainty Level
 Final Rating: 0 - Trivial
 1 - Highly-controlled
 2 - Well-controlled
 3 - Controlled
 4 - Poorly-controlled

Certainty Level
 1 - High (>0.75)
 2 - Medium (0.5-0.75)
 3 - Low (<0.5)

Basis
 Likelihood Decision Chart
 Posterior Decision Chart

Post

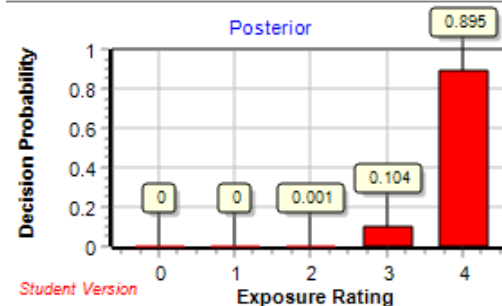
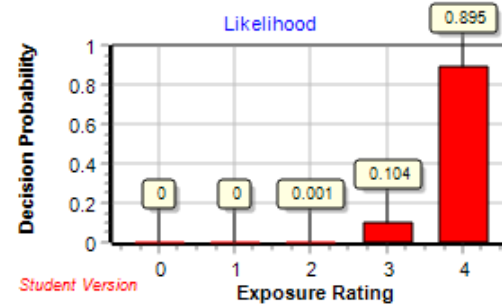
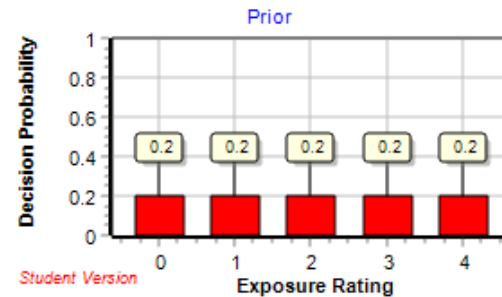
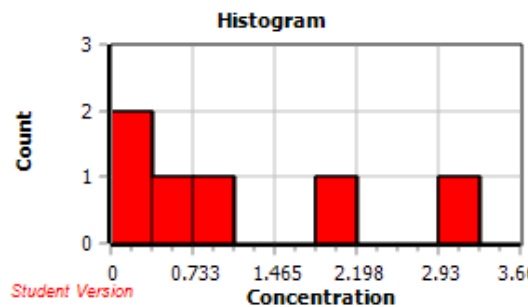
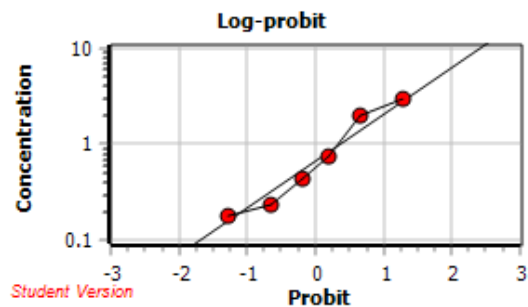
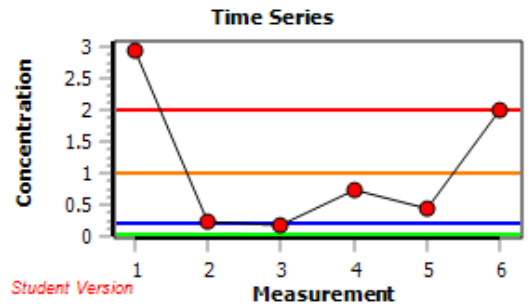
WARNING:
 Use the professional IHDA for datasets containing non-detects.
 The Student version of BDA is not designed to handle non-detects.

Decision Probability vs Exposure Rating (Likelihood):
 0: 0, 1: 0, 2: 0.001, 3: 0.104, 4: 0.895

Decision Probability vs Exposure Rating (Posterior):
 0: 0, 1: 0, 2: 0.001, 3: 0.168, 4: 0.811

MORE FROM IHDA_STUDENT

Bayesian Decisions Analysis Charts



SAMPLE IS 0.22, OEL IS 2.

IHDataAnalyst-Student 2018b

File View Calculate Graphs Options Help

Calculate All GOF Graphs Statistics BDA Charts

Data GOF BDA Initial Rating CDA

Facility Information

Facility: TwaTest 1

Department: _____

Building: _____

Process: _____

Task: _____

Substance Information

Substance: _____

OEL: 2

Comments: For Day 41

	CASE	CONC	<LOD	DATE	GROUP
1	1	0.22			
2					

Statistics GOF Graphs BDA Charts CDA

Bayesian Decision Charts:

Type of prior decision distribution:
Uniform prior

Rating: 0-T 1-HC 2-WC 3-C 4-PC
Cutoff (%OEL): 1.0 10.0 50.0 100.0 >100.0

Prior 0.200 0.200 0.200 0.200 0.200
Likelihood 0.000 0.033 0.651 0.154 0.162
Posterior 0.000 0.033 0.651 0.154 0.162

Cum Likelihood 0.000 0.033 0.684 0.838 1.000
Cum Posterior 0.000 0.033 0.684 0.838 1.000

Parameter space: GMmin = 0.000408951 GMmax = 10
GSDmin = 1.05 GSDmax = 4

IHDataAnalyst-Student 2018b

File View Calculate Graphs Options Help

Calculate All GOF Graphs Statistics BDA Charts

Data GOF BDA Initial Rating CDA

Categorical

Prior Decision Distribution

Uniform Prior

Rating Probability

0 - Trivial 0.200

1 - Highly-controlled 0.200

2 - Well-controlled 0.200

3 - Controlled 0.200

4 - Poorly-controlled 0.200

Certainty Level: _____ Sum = _____

Prior Decision Distribution

Decision Probability

0.2 0.2 0.2 0.2

Rating

0 1 2 3 4

Bars and Labels

Solid bars

Colored bars

Select Final Rating and Certainty Level

Final Rating

0 - Trivial

1 - Highly-controlled

2 - Well-controlled

3 - Controlled

4 - Poorly-controlled

Certainty Level

1 - High (>0.75)

2 - Medium (0.5-0.75)

3 - Low (<0.5)

Basic

Likelihood Decision Chart

Posterior Decision Chart

Post

WARNING:

Use the professional IHDA for datasets containing non-detects. The Student version of BDA is not designed to handle non-detects.

Decision Probability

0.2 0.2 0.2 0.2

Exposure Rating

0 1 2 3 4

Student Version

Decision Probability

0.033 0.651 0.154 0.162

Exposure Rating

0 1 2 3 4

Student Version

Decision Probability

0.033 0.651 0.154 0.162

Exposure Rating

0 1 2 3 4

Student Version

> OEL 0.162

Uniform prior (we have no clue re category)

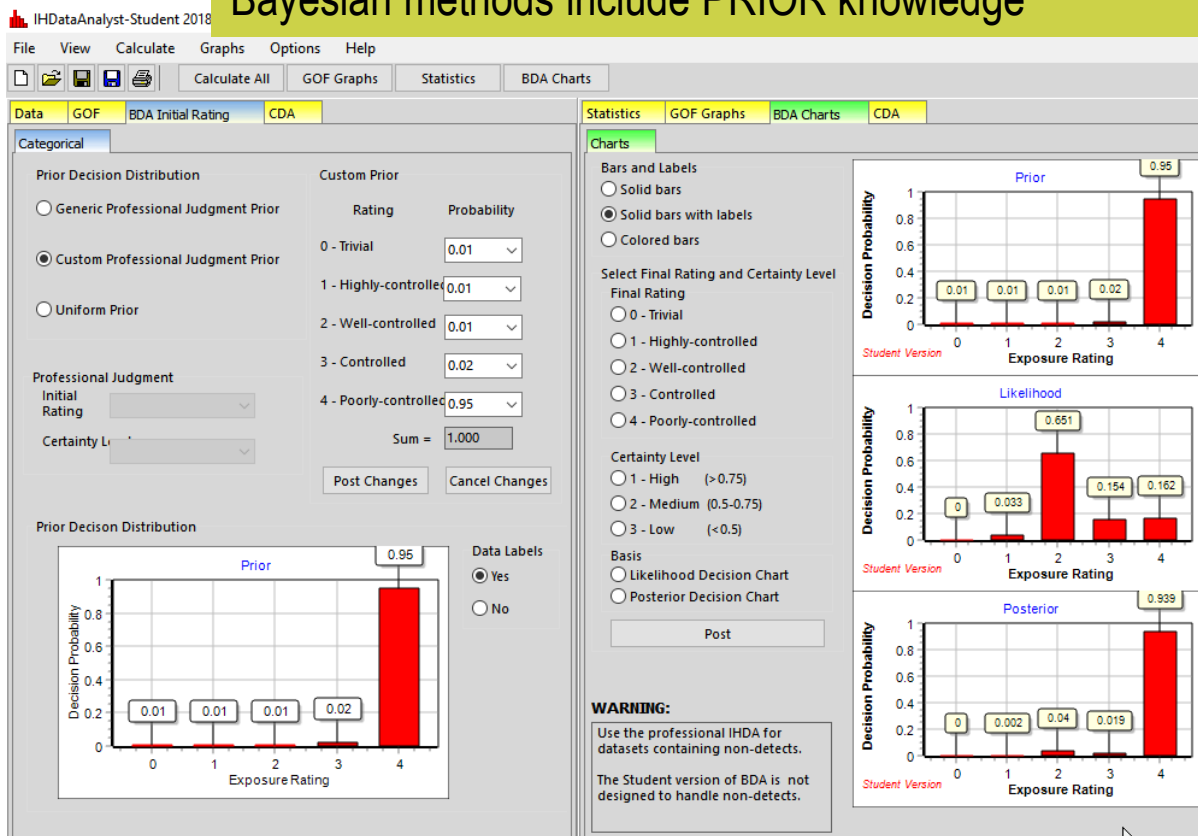
IN A BAYESIAN ANALYSIS, “WHAT IF....”

We say IN OUR OPINION the n=1 value is off, and is way low.

We can use a “more informed” prior.

This is a key to Bayesian power. Frequentist statistics use current data only.

Bayesian methods include PRIOR knowledge



We may not always be this MATHEMATICAL in Industrial Hygiene when we use judgement and opinion with limited data.

MAYBE WE SHOULD BE!!!!

Note admitting “we do not know” in this situation of n=1, we came to a “safe” conclusion with the “uniform” prior or our highly skeptical prior

THERE IS ANOTHER BAYESIAN TOOL AVAILABLE

[HTTP://WWW.EXPOSTATS.CA/SITE/EN/INDEX.HTML](http://www.expostats.ca/site/en/index.html)

WEB BASED BUT OFFLINE VERSION AVAILABLE

EXPOSTATS
BAYESIAN CALCULATOR

STATISTICAL TOOLS FOR THE INTERPRETATION OF INDUSTRIAL HYGIENE DATA

HOME INTERPRETATION TOOLS PROJECT WEBEXPO OTHER TOOLS LINKS CONTACT

EXPOSTATS
Statistical tools for the interpretation of industrial hygiene data

FIND OUT MORE

Overview

This website aims to serve as a hub for online tools helping occupational hygiene practitioners perform risk assessment. The heart of www.expostats.ca is a Bayesian calculation engine allowing to estimate parameters of the distribution of exposure for a worker or group of workers. The user enters measurement data and the website performs calculations and returns risk metric estimates as well as uncertainty estimates.

www.expostats.ca is in constant evolution, as new tools are being developed, existing ones are being validated, and new, creative ways to communicate risk are explored. We warmly welcome any questions, suggestions or remarks.

Home Page

EXPOSTATS
BAYESIAN CALCULATOR

STATISTICAL TOOLS FOR THE INTERPRETATION OF INDUSTRIAL HYGIENE DATA

HOME INTERPRETATION TOOLS PROJECT WEBEXPO OTHER TOOLS LINKS CONTACT

Interpretation Tools

- Tool 1: Estimation of parameters of the lognormal distribution and comparison to an occupational exposure limit (OEL)
- Tool 2: Comparison to an occupational exposure limit (OEL) while accounting for within and between-worker variations
- Tool 3: Assessment of the effect of a categorical variable: Determinants of exposure analysis
- Multi-Tool (Offline)

Last updated: 2018-12-13 13:35:03

Interpretation Tools Tab

Currently EXPOSTATS has a preconfigured prior. It works well. A future version may have more prior specification flexibility

Calculation parameters

Exposure limit:

Exposure limit multiplier:

Credible interval probability:

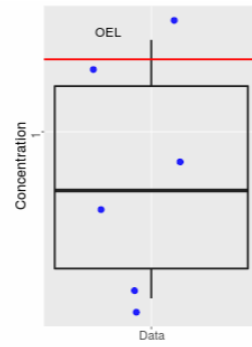
Overexposure risk threshold:

Data

2.93
0.23
0.18
0.74
0.44
1.98

Descriptive statistics

parameter	value
n	6
Proportion censored	0
Minimum	0.18
25th percentile	0.283
Median	0.59
75th percentile	1.67
Maximum	2.93
Proportion >OEL	17%
Arithmetic mean	1.08
Arithmetic standard deviation	1.12
Coefficient of variation	104%
Geometric mean	0.654
Geometric standard deviation	3.1

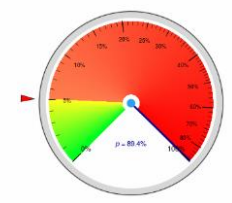


Risk analysis based on the exceedance fraction

Exceedance threshold:

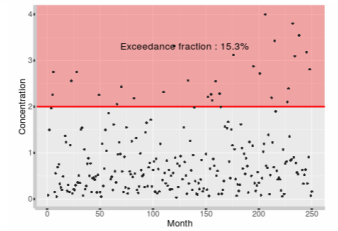
Risk decision

- > Criterion defining overexposure: Exceedance fraction $\geq 5\%$
- > Uncertainty management : based on the Bayesian model, the probability that this criterion is met (overexposure risk) is: 89.4%
- > Uncertainty management : The probability of overexposure (overexposure risk) should be: < 5%
- > As a consequence, the current situation is declared: Poorly controlled



Sequential plot

The sequential plot presents the estimated exposure distribution assuming 250 exposure measurements have been collected. If the measurements represent 8h TWA values, this would represent approximately a full year of exposure. The OEL is shown as a red horizontal line.



Estimated parameters

Estimated parameters - Distribution

The estimate of the geometric mean and its interval of credibility (90%) are: **0.65 [0.29 - 1.5]**

The geometric standard deviation estimate and its credibility interval (90%) are: **3 [2.1 - 6.2]**

Estimated parameters - Exceeding fraction

The estimate is: **15.3%**

The credibility interval (90%) is: **[3.23 - 41]**

Estimated parameters - 95th percentile

The estimate is: **4**

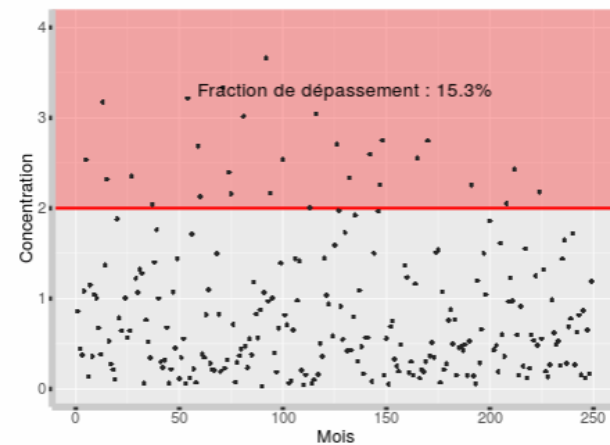
The credibility interval (90%) is: **[1.68 - 18.2]**

Estimated Parameters - Arithmetic Mean

The estimate is: **1.23**

The credibility interval (90%) is: **[0.572 - 4.92]**

Sequential graphic



The sequential graph represents the estimated distribution of exposures assuming 250 measurements were taken. If the measurements represent 8h weighted values, this is approximately a year of exposure. The ELV is in red.

EXPOSTATS.CA FOR N=1, 0.22, ESTIMATED PARAMETERS (BAYESIAN)

Calculation parameters

Exposure limit

Exposure limit multiplier

Credible interval probability

Overexposure risk threshold

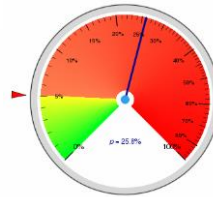
Data

Risk analysis based on the exceedance fraction

Exceedance threshold

Risk decision

- Criterion defining overexposure:
Exceedance fraction $\geq 5\%$
- Uncertainty management : based on the Bayesian model, the probability that this criterion is met (overexposure risk) is:
25.8 %
- Uncertainty management : The probability of overexposure (overexposure risk) should be:
< 5%
- As a consequence, the current situation is declared:
Poorly controlled



Risk analysis based on the 95th percentile

Selection of the critical percentile

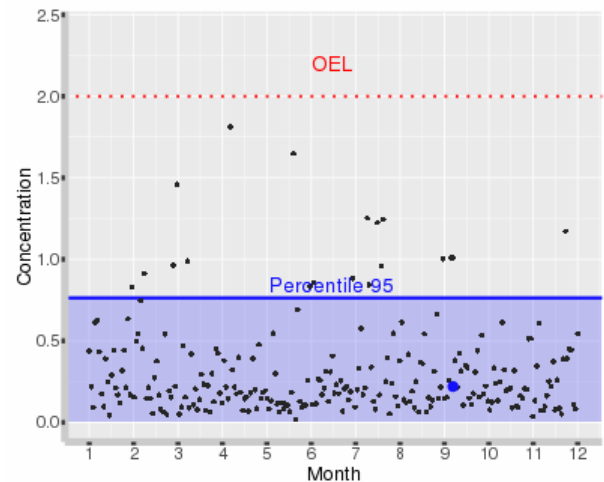
Risk decision

- Criterion defining overexposure:
95th percentile \geq OEL
- Uncertainty management : based on the Bayesian model, the probability that this criterion is met (overexposure risk) is:
25.8 %
- Uncertainty management : The probability of overexposure (overexposure risk) should be:
< 5%
- As a consequence, the current situation is declared:
Poorly controlled



Sequential plot

Assuming the underlying distribution of exposure would occur over a year, the graph below shows a simple sequential plot of the approximate 240 days of exposure. The OEL is shown as a dashed red horizontal line. The point estimate of the selected percentile is shown as a blue continuous line.



■ Measured, randomly placed

EXPOSTATS Tool 2. Within and Between Worker Variability (data by J. Lavoue)

Calculation parameter

Exposure limit

Exposure limit multiplier

Credible interval probability

Overexposure risk threshold

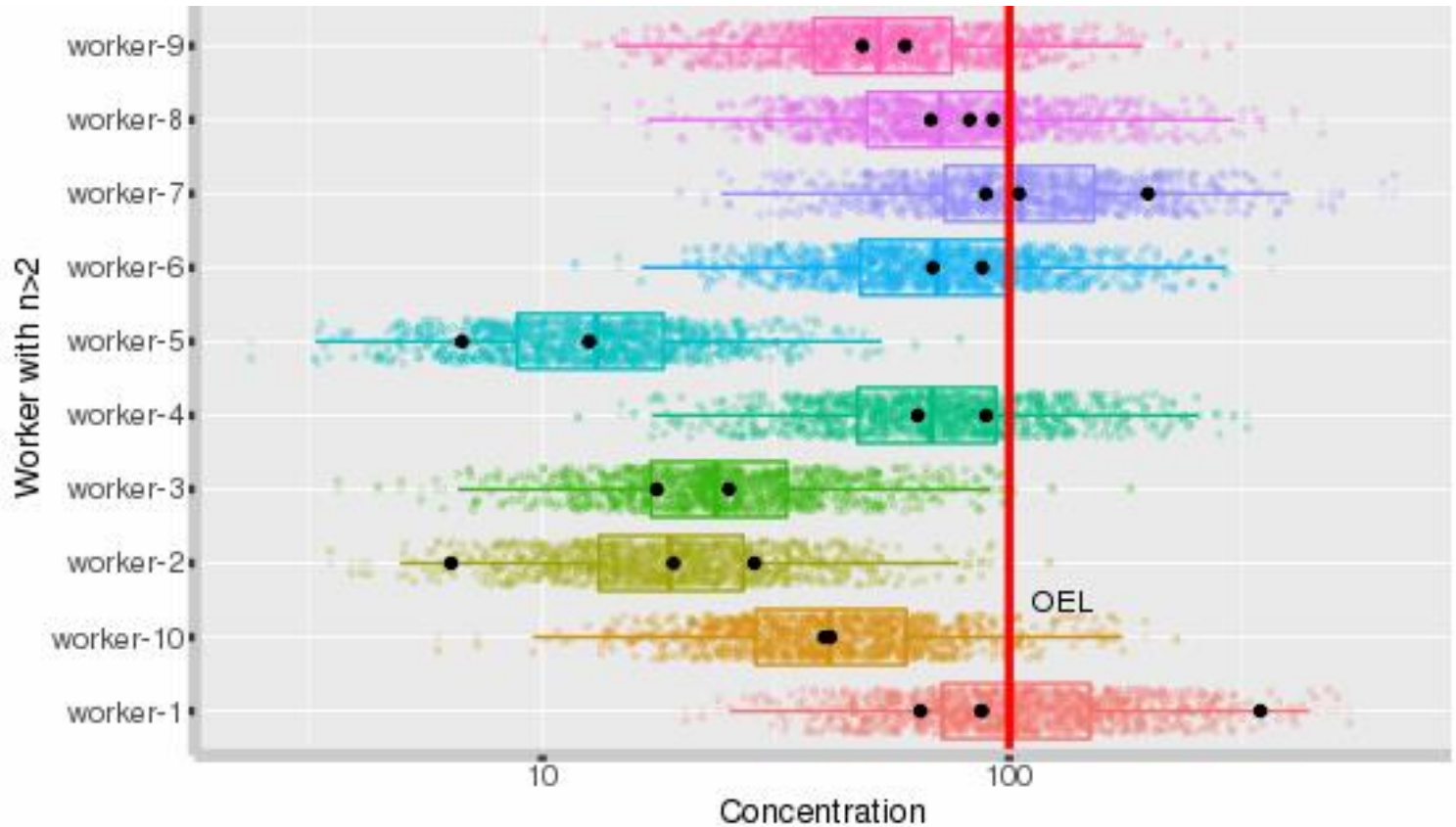
Rb ratio coverage

Within-worker correlation threshold

Data

40.1	worker-10
28.5	worker-2
48.5	worker-9
87	worker-1
6.73	worker-5
105	worker-7
64.6	worker-1
87.5	worker-6
6.38	worker-2
68.6	worker-6

Differences Between Workers (with at least n=3)



EXPOSTATS WORKER BY WORKER ANALYSIS

Risk analysis based on the exceedance fraction

Exceedance threshold

5

Group analysis

Between worker analysis

Individual worker results

In this panel you can obtain individual risk assessment for any worker. Workers can be selected using the dropdown menu below. Be aware that important uncertainty will be associated with these estimates, especially those based on very few measurement. The results are based on the Bayesian analysis of variance of the whole group, not restricted to individual worker data.

Select a worker

worker-1

- worker-1
- worker-10
- worker-2
- worker-3
- worker-4
- worker-5
- worker-6
- worker-7

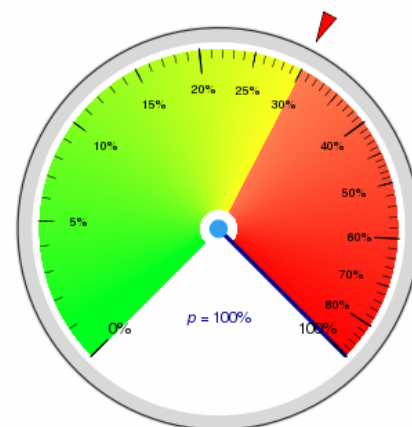
Bayesian model, the probability that this criterion is met (overexposure risk) is:

► Uncertainty management : The probability of overexposure (overexposure risk) should be:

< 30%

► As a consequence, the current situation is declared:

Poorly controlled



Do You Remember our Baseline Strategy Simulator Exercise? With $n=1$ or 2, or ... the BAYESIAN tools may have delivered more reliable information to support the critical decisions.

THERE WILL BE PROBLEMATIC DATA SETS

- Data are neither normal nor lognormal
- Data have a WILD GSD
 - Is it a mixed distribution? Should data be stratified? HOW could you check this?
 - Did a truly exceptional event occur? Should a data point be censored?
 - Is one worker different from others in the group?
- Limit of detection samples are quite prevalent
 - LOD replacement methods
 - Bayesian tools including censored data approaches
- The analytical method is very imprecise or biased
 - Use a better method next time
 - Adjust for the bias
- The samples are of mixed and significantly different duration and were not adjusted to a standard STEL or TWA duration
 - Stratify the data
 - Adjust to a standard duration
 - Can you make legitimate and suitable assumptions on unsampled time?
- Other problems

STATISTICAL METHODS NOT COVERED (CONSIDERED ADVANCED TOPICS REQUIRING A FULL PDC)

1. Within and between worker variability (several slides prior)
2. Dealing with prevalent non-detects
3. Nonparametric methods
4. Analysis of variance for improving SEGs
5. Goodness of fit tests and importance for inferential statistics

IMHO, EXPOSTATS with Bayesian logic,

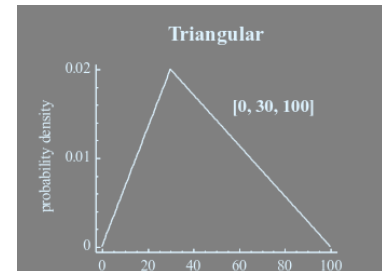
- a) gives robust approaches to 1,
- b) handles 2 well,
- c) reduces the need for 3 (and non-parametric methods usually need a good sized data set),
- d) does well with 4 via within and between worker analysis (Tool 2) and group to group differences (Tool 3).
- e) Covers 5 as does IH Stat and IHDA

COMMONLY USEFUL PROBABILITY DISTRIBUTIONS

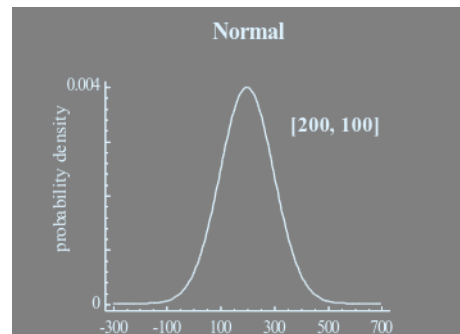
- Uniform (Just a range, $n1$ to $n2$)

Uniform $n1$ \longleftrightarrow $n2$

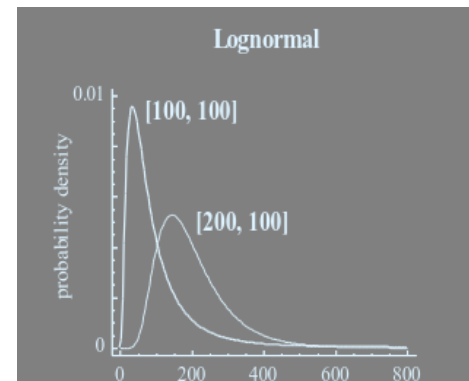
- Triangular (Min, Max, Most Likely)



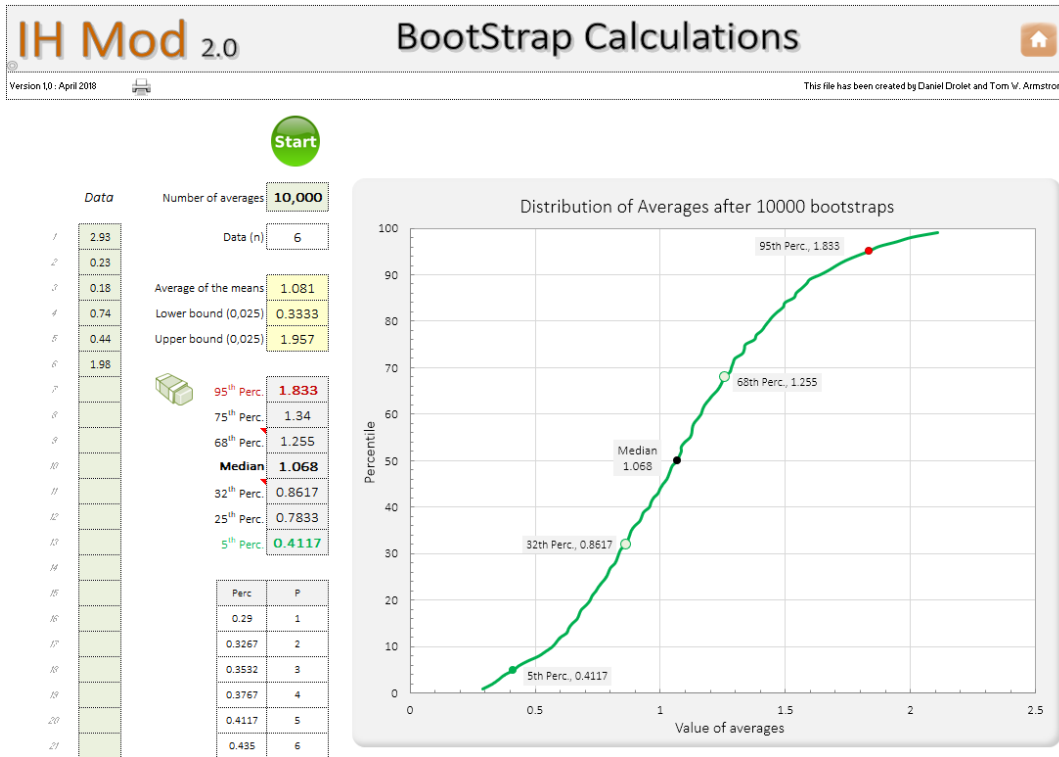
- Normal (AM, SD)



- LogNormal (AM or GM, GSD)



WHAT IF YOUR DATA DO NOT FIT A DISTRIBUTION FOR INFERENTIAL STATISTICS? TRY IH MOD SUPPORT FILE, BOOTSTRAP FOR MEAN AND ITS CI



At AIHA EASC Volunteer group Web page

<https://www.aiha.org/get-involved/VolunteerGroups/Pages/Exposure-Assessment-Strategies-Committee.aspx>

FOR MORE INFORMATION....

- AIHA Body of Knowledge Occupational Exposure Risk Assessment/Management
- <https://www.aiha.org/membercenter/SynergistArchives/2014SynergistArchives/Pages/JudgmentDay-01.aspx>
- <https://www.aiha.org/publications-and-resources/TheSynergist/SynergistNow/Lists/Posts/Post.aspx?ID=22>
- Fundamentals: Bayes' Theorem
<https://www.youtube.com/watch?v=OqmJhPQYRc8>
- EXPOSTATS.CA <http://www.expostats.ca/site/en/tools.html>
(Expostats: A Bayesian Toolkit to Aid the Interpretation of Occupational Exposure Measurements, *Annals of Work Exposures and Health*, 2018, 1–13, doi: 10.1093/annweh/wxy100, Jérôme Lavoué, et al., E-mail: jerome.lavoue@umontreal.ca)
- And, of course, *A Strategy for Assessing and Managing Occupational Exposures*, Bullock et al., AIHA Press