The Importance of SEG Development

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Exposure Assessment Strategies

- Exposures vary between workers, over time, shift, and location.
  - The sampling strategy should be effective in capturing this variability.
- At the same time, the strategy must be feasible and efficient in that it should not require an inordinately large number of samples.
  - Occupational hygienists usually operate with limited resources that preclude large sample sizes, which can lead to variability being underestimated.
- Similar exposure groups (SEGs) should be developed to assist in performing the exposure assessment.

Forming SEGs and Exposure Groups (EGs)

- Formation of SEGs should flow from the Basic Characterization following a systematic exposure assessment approach, based on defined criteria.
- During the Basic Characterization, exposure determinants are identified .
  - Job assignment, frequency, duration, engineering and other controls, etc.
- Each SEG will have a single exposure distribution.
- Workers may rotate through job assignments and thus may belong to multiple SEGs, with different exposure distributions.
- EGs will often be comprised of multiple SEGs.[1]

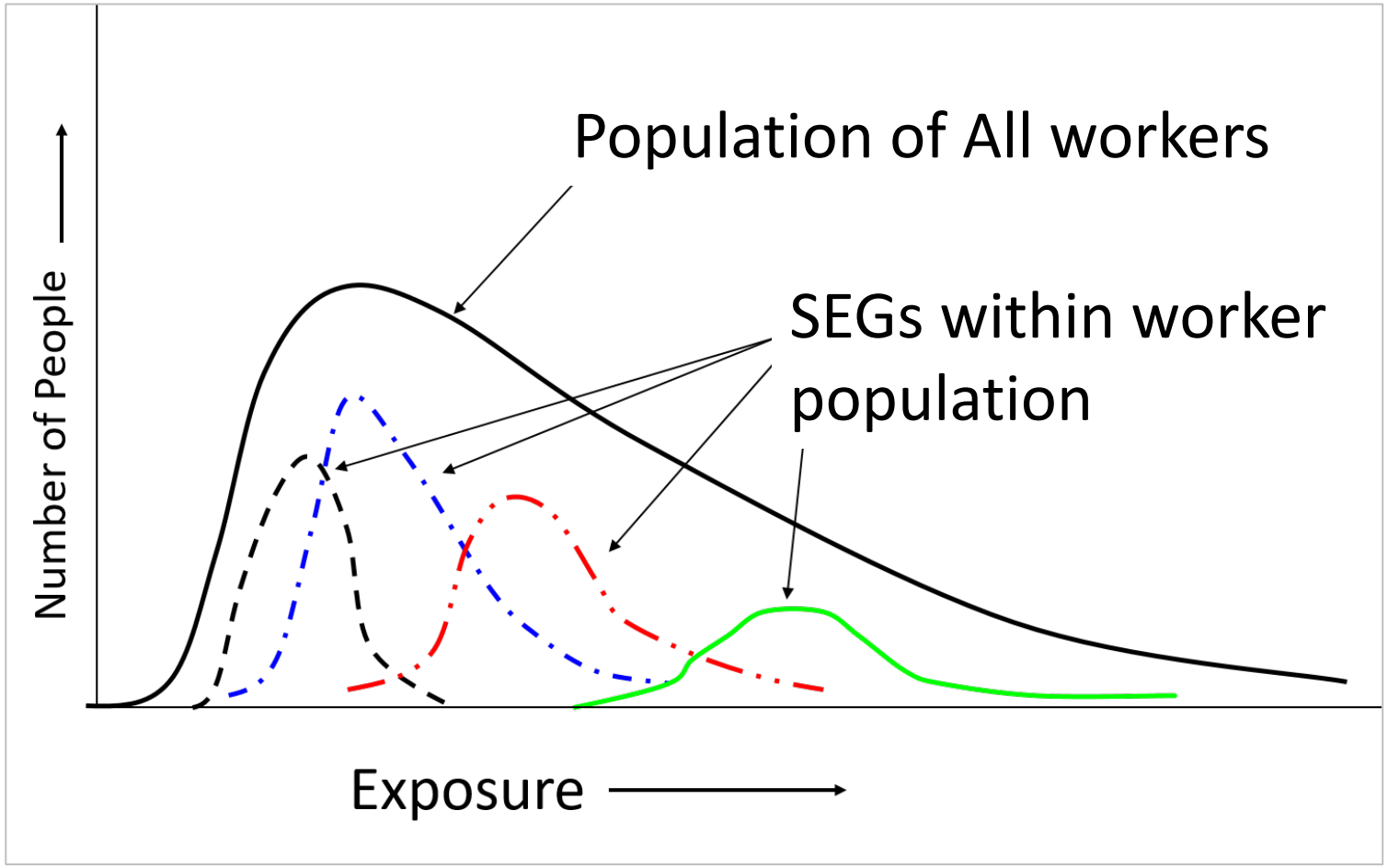
1. Mark R Stenzel, Caroline P Groth, Tran B Huynh, Gurumurthy Ramachandran, Sudipto Banerjee, Richard K Kwok, Lawrence S Engel, Aaron Blair, Dale P Sandler, Patricia A Stewart, Exposure Group Development in Support of the NIEHS GuLF Study, *Annals of Work Exposures and Health*, Volume 66, Issue Supplement_1, April 2022, Pages i23–i55, https://doi.org/10.1093/annweh/wxab093

EPA's Approach to Developing EGs and SEGs

- EPA develops Occupational Exposure Scenarios (OESs) and Consumer Exposure Scenarios (CESs) for the purposes of exposure and risk assessment.
- These may be consistent with the definition of an EG or sometimes an SEG .
- When an exposure assessment must be performed for an EG, additional considerations on data selection and evaluation are warranted to ensure that EG estimates are representative of exposures and limit uncertainty in the exposure assessment results. Factors such as controls can be especially important for broader EGs when evaluating exposure potential.

The Observational Approach to Creating Similar Exposure Groups (SEGs)

Exposure Distributions within the Worker Population in a Workplace



Within-Worker and Between-Worker Variability

Variability divided into within-worker and between-worker variability

- Within-worker variability refers to the variability of the exposure of an individual worker obtained from repeated measurements over time (assuming that no systematic changes in the work environment have taken place over this time). This arises due to variability in the workplace environment.

Within-Worker and Between-Worker Variability

- Between-worker variability refers to variations in the mean exposures between individual workers that arise due to differences in their tasks and work activity patterns.
- Thus, understanding the source of variability has important implications for exposure control decisions.

Prospective or Observational Approach

- On the basis of an a priori understanding of the processes and tasks that each group of workers are engaged in
- Corn and Esmen (1979)—observational approach
- Workers were prospectively grouped into so-called "exposure zones" on the basis of:
  - Work similarity (similar profiles of job tasks)
  - Similarity of hazardous agents (similar chemicals to which they are exposed)
  - Environmental similarity (controls implemented, ventilation characteristics, processes, etc.)

Source: Corn, M., & Esmen, N. A. (1979). Workplace exposure zones for classification of employee exposures to physical and chemical agents. *Am Ind Hyg Assoc J, 40*(1), 47–57. Retrieved from https://doi.org/10.1080/15298667991429318.

Challenging the Observational Approach

- Kromhout and Rappaport challenged the observational approach.
- Analyzed worker groups (183) obtained from 45 different published studies with a minimum of two personal measurements per worker in each group.
- The analysis-of-variance (ANOVA) model used to determine the between-worker and within-worker components of variance in each worker group.
- Roughly 80% of the groups had workers who were not similarly exposed.

HANS KROMHOUT, ELAINE SYMANSKI, STEPHEN M. RAPPAPORT, A COMPREHENSIVE EVALUATION OF WITHIN- AND BETWEEN-WORKER COMPONENTS OF OCCUPATIONAL EXPOSURE TO CHEMICAL AGENTS, The Annals of Occupational Hygiene, Volume 37, Issue 3, June 1993, Pages 253–270, https://doi.org/10.1093/annhyg/37.3.253

Challenging the Observational Approach

- If individual workers have exposures that are significantly different, then the differences most likely arise due to differences in individual tasks and work practices, and not differences in the environment.
- An observational classification approach may not be able to detect these differences, and thus cause misclassification.
- Rappaport proposed a retrospective classification scheme where the entire population of workers is randomly sampled, and subsequently divided into groups such that for each group does not exceed 2.
- Such groups are called monomorphic groups.

Rappaport, S. M. (1991). Selection of the Measures of Exposure for Epidemiology Studies. Applied Occupational and Environmental Hygiene, 6(6), 448–457. https://doi.org/10.1080/1047322X.1991.10387912

Sampling Approach

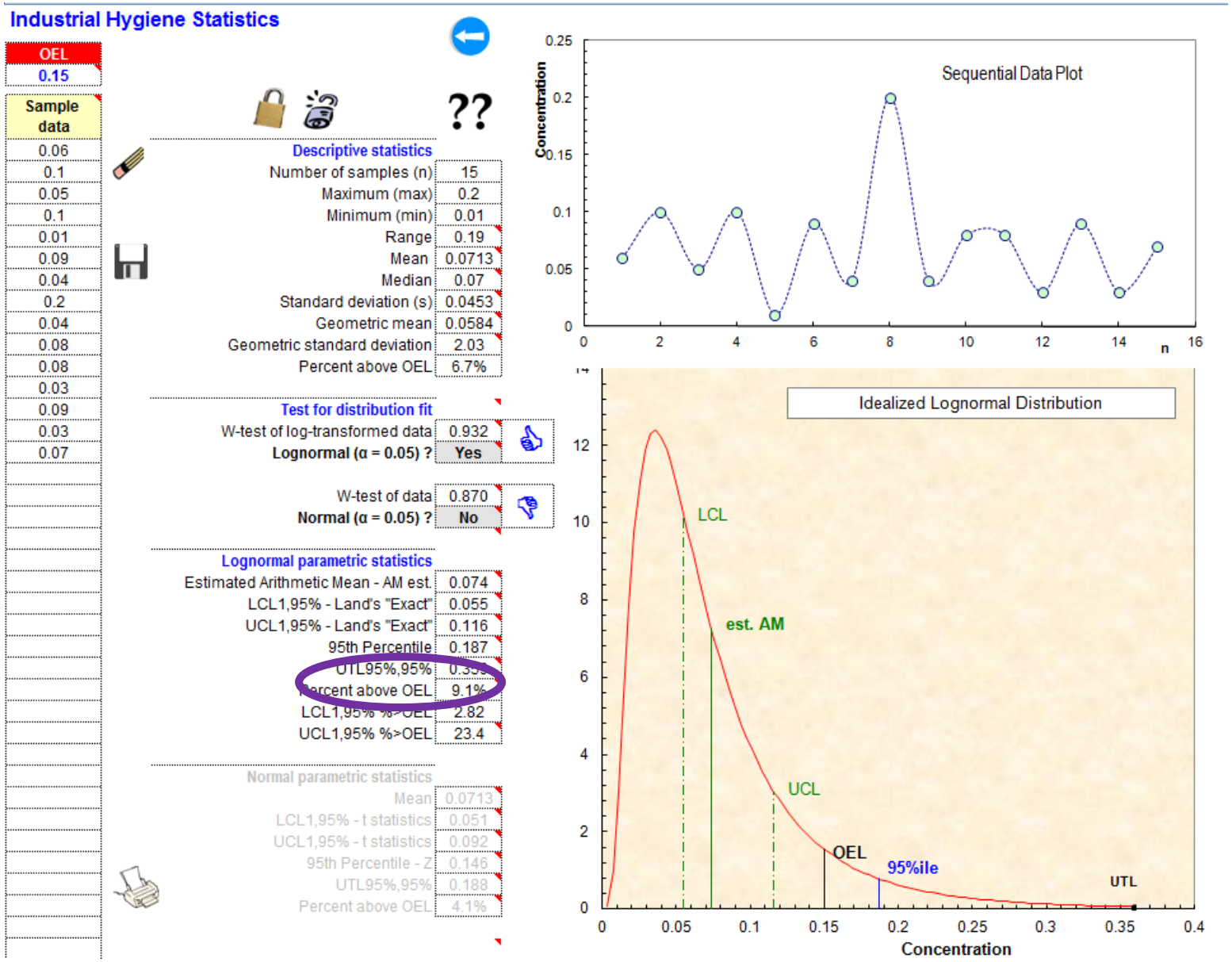
- Instead of a GSD = 2, the HSE of the U.K. and the AIHA prefer or suggest that for each group, the GSD should not exceed 4.
- This approach requires multiple measurements of the sampled workers' exposures to estimate the between- and within-worker components of variance.
- Since the classification of workers is done after sampling, this approach is commonly referred to as the sampling approach to classification.

Table IV.8 – Sample Size Needed for Using $UTL_{95\%,95\%}$ to Show 95% Confidence that 95th Percentile is Below the OEL (Power = 0.80)

True 95th percentile/OEL	*GSD = 2.03*	*GSD = 2.72*	*GSD = 3.04*	*GSD = 4.11*	*GSD = 4.86*
0.67	58	107	154	202	249
0.5	24	42	59	76	93
0.4	16	27	37	47	57
0.33	13	20	28	35	42

*Adapted from Lyles R.H. and L.L. Kupper: On strategies for comparing occupational exposure data to limits. Am. Ind. Hyg. Assoc. J. 57(1):*6–15 (1996).

IH Stat Tool



Developed by AIHA, available for free on AIHA website

EXPOSTATS Tool

Tool1: Data interpretation for one similarly exposed group

Calculation parameters

Exposure limit

100

Exposure limit multiplier

1

Credible interval probability

90

Overexposure risk threshold

30

Data

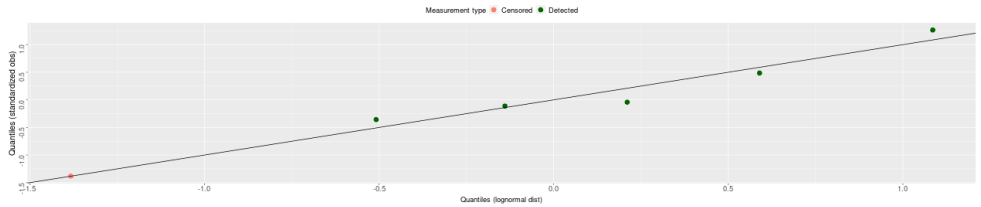
28.9
19.4
<5.5
149.9
26.42
56.1

Descriptive | Exceedance | 95th percentile | Arithmetic mean | Instructions | About | Methodological background

Descriptive statistics

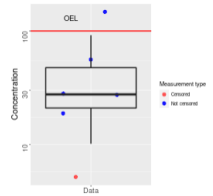
parameter	value
n	6
Proportion censored	17 %
Minimum	< 5.5
25th percentile	21.2
Median	27.7
75th percentile	49.3
Maximum	150
Proportion >OEL	17 %
Arithmetic mean	47.7
Arithmetic standard deviation	52.8
Coefficient of variation	111 %
Geometric mean	29.5
Geometric standard deviation	3.04

Quantile-quantile plot



In the qqplot above, the points should approximately follow the estimated regression line. Random deviations from the line is to be expected. Any important deviation would suggest the data may have to be split into separate subsets, or some outliers should be investigated.

Box and whisker plot



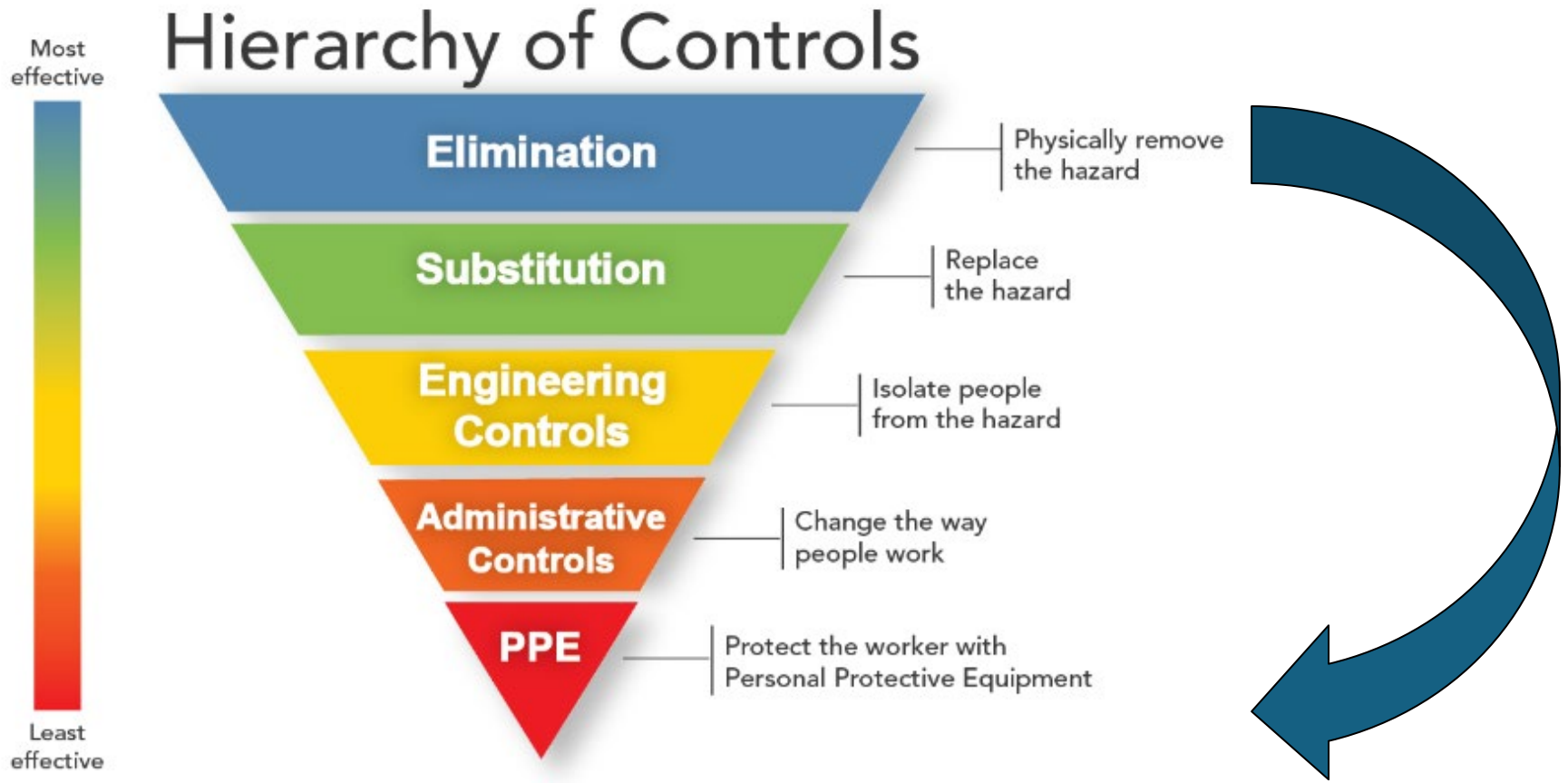
The graph above shows a descriptive box and whisker plot of the data, with the actual observations randomly jittered around the x-axis middle-point. The box is defined by the 25th and 75th percentiles, and the whiskers by the 10th and 90th percentiles.

Note

For these analyses, censored data are treated using the following procedure : interval censored data are imputed as the mid-range, right censored data are imputed as 9/4 of the censoring point, and left censored data are treated using technique called "Robust regression on order statistics", or "Log-probit regression" using an algorithm based on the NDexpo, that tool itself based on work by Dennis Helsel.

Using Bayesian statistical methods to characterize exposure data.
Available for free, at https://expostats.ca/shiny/outils/tool1en/

The Hierarchy of Controls for Exposure Assessment



https://www.cdc.gov/niosh/topics/hierarchy/default.html

Strengthening EPA's Approach to Developing EGs and SEGs

- When defining SEGs and EGs, start with a basic characterization to identify the critical determinants of exposure with the greatest influence on exposures (i.e., work practices, exposure controls, etc.). Statistical approaches have been developed to evaluate the representativeness of exposure estimates for a given EG or SEG[1].
- SEGs allow for an efficient and realistic assessment of exposures when appropriately constructed.
- When SEGs and especially if EGs must be used, consider the available statistical tools such as the GSD and statistical profile of the available data.

1. Huynh TB, Groth CP, Ramachandran G, Banerjee S, Stenzel M, Quick H, Blair A, Engel LS, Kwok RK, Sandler DP, Stewart PA. Estimates of Occupational Inhalation Exposures to Six Oil-Related Compounds on the Four Rig Vessels Responding to the Deepwater Horizon Oil Spill. Ann Work Expo Health. 2022 Apr 7;66(Suppl 1):i89-i110. doi: 10.1093/annweh/wxaa072. Erratum in: Ann Work Expo Health. 2022 Apr 7;66(Supplement_1):i247-i249. PMID: 33009797; PMCID: PMC8989034.

Questions?

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