HAND ARM VIBRATION

International conference

6-9 JUNE 2023

Espace Prouvé,
Nancy, France

Determination of the Number of Measurements Required for 95% Confidence in an Upper Quartile Value of Hand-Arm Vibration Measurement Using the Monte-Carlo Method

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UK

RESEARCH AND GUIDANCE FROM HSE

Objective

To determine:

- The number of measured hand-arm vibration data sets that will provide

  an estimate of the **upper quartile value** that is

  within 10% of the true value **with 95% confidence**

Part of wider project on how to demonstrate vibration emission of low-vibration machines

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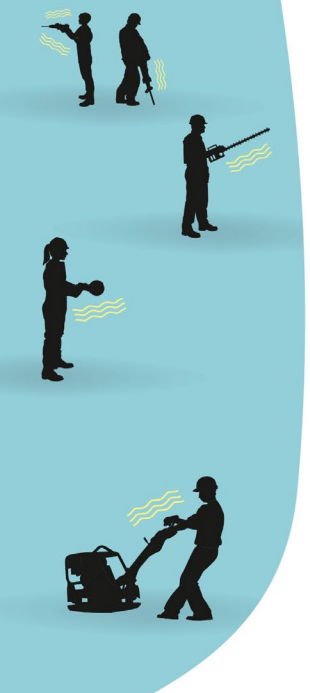
Method

- Use the HSE Hand-Arm Vibration Database
  - Assess how data sets could be modelled using random number data sets
- Use the Monte Carlo method
  - Generate large numbers of simulated HAV data sets with:
    - Known target upper-quartile value and viariability
    - Varying numbers of sample in data set
  - Assess the computed 75th percentile values and
  - Determine how many samples are required to get within 10% of the target value.



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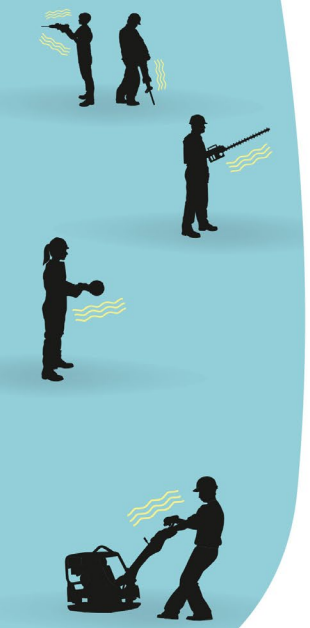
HAV data sets



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HSE Hand-Arm Vibration Database

- Database interrogated in April 2020
- Machines for which:
  - more than 20 measurements on the same machine
- 135 machines
- Measurements are:
  - all real work activities
  - not multiple repeats of the same activity

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HSE Hand-Arm Vibration Database

- Percentile statistics of the vibration total values were calculated for each of the 135 machines:
  - numbers in the data sets ranged from 21 to 216
  - median number of samples: 30
  - median 75th percentile: 11.24 m/s²
- IQR/Q75 (“*variability*”)
  - measure of variability, independent of actual vibration values
  - median IQR/Q75: 0.31 *(Range from 0.10 to 0.63)*

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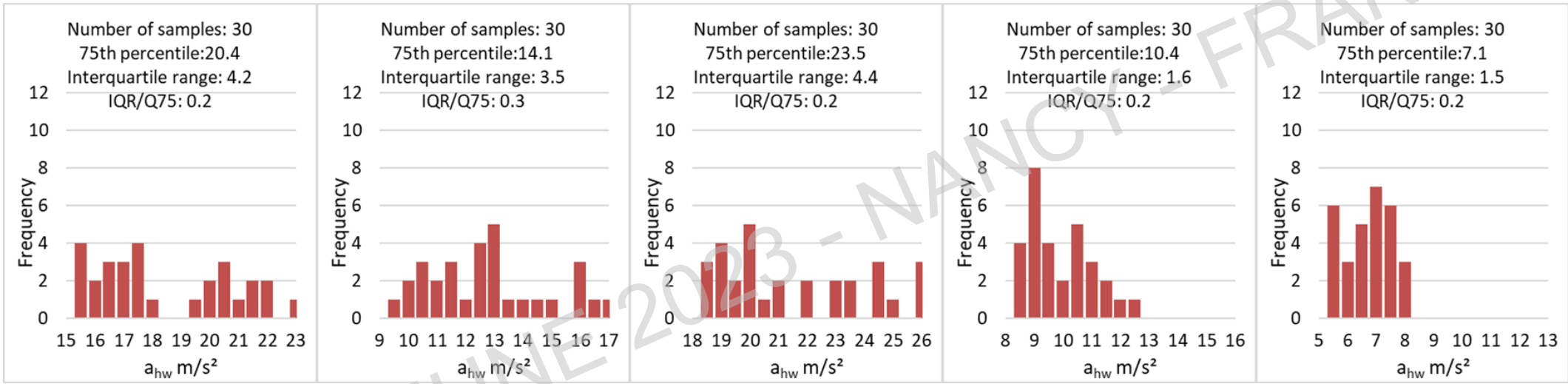
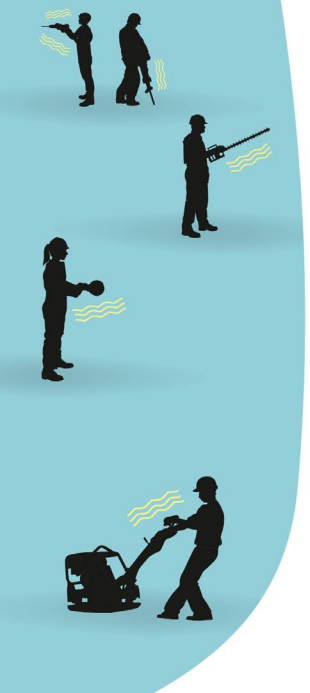
Example data sets from HSE data base (sets with 30 samples)





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Simulation of HAV data sets

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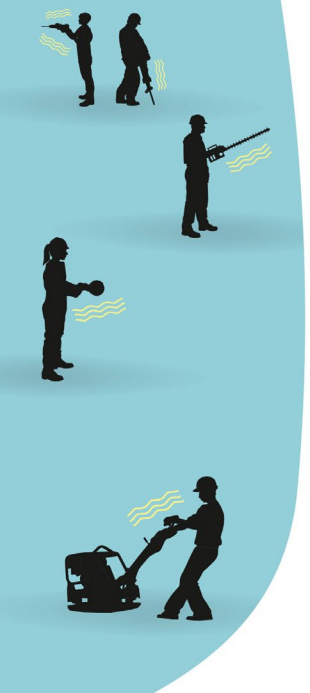
Simulation of HAV data sets

Uniform random number generator:

- Target 75th percentile (Q75): 10 m/s²
  - Median database Q75 value: 11.24 m/s²
- IQR/Q75 ("*variability*"): 0.1 to 0.6
  - Median database IQR/Q75 value: 0.31



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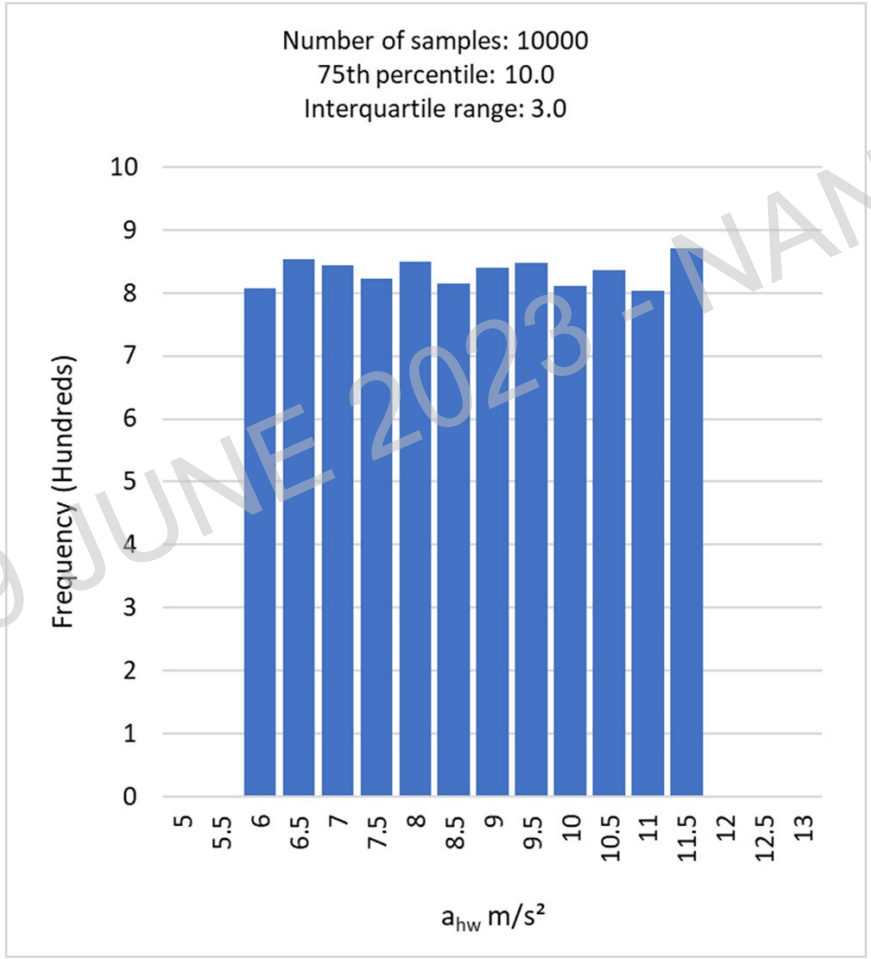
Uniform distribution – 10,000 samples



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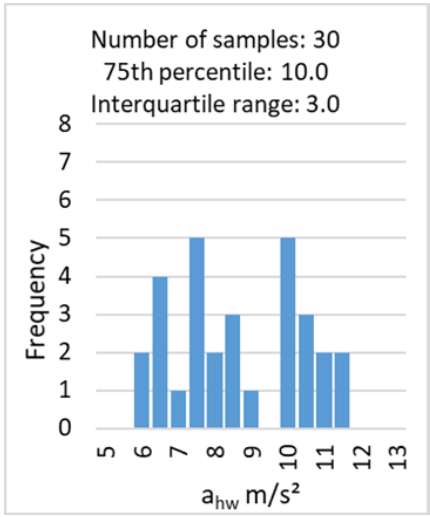
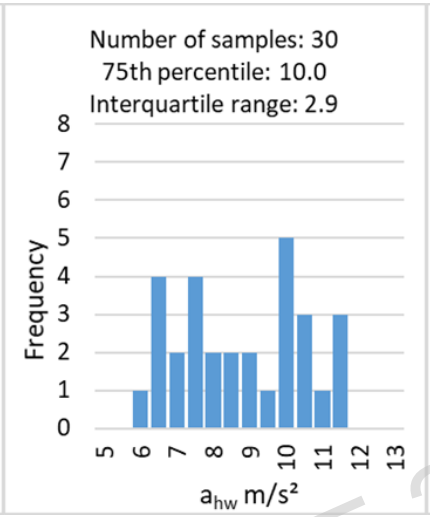
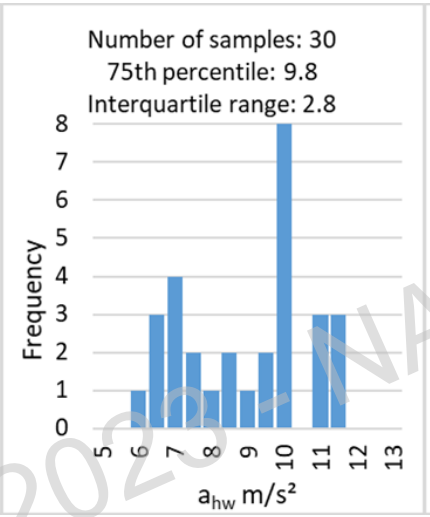
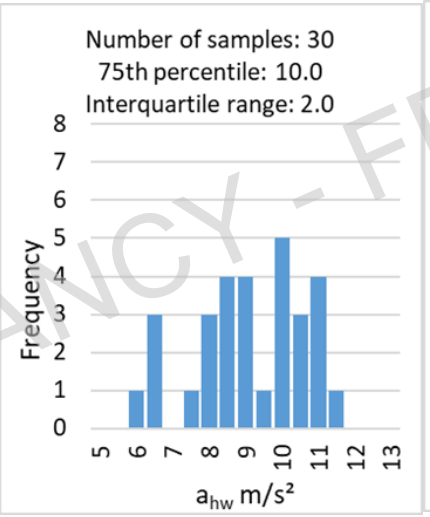
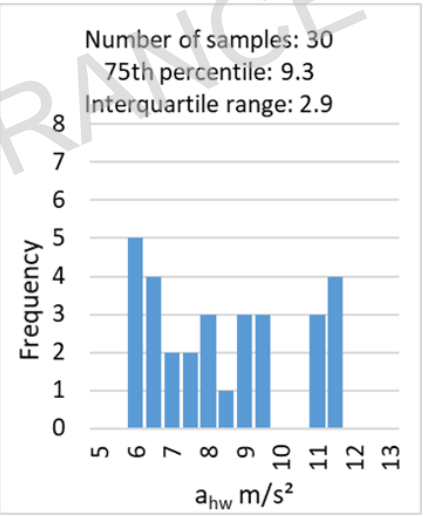
Uniform distributions - 30 samples











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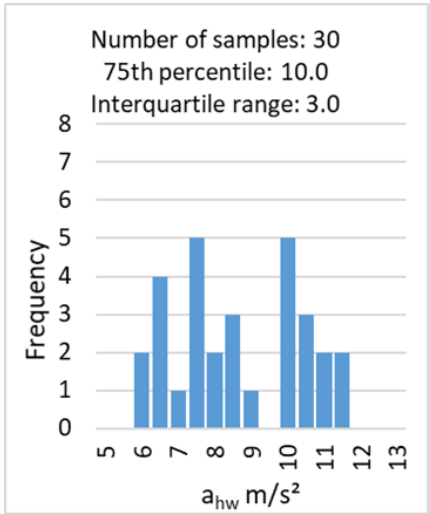
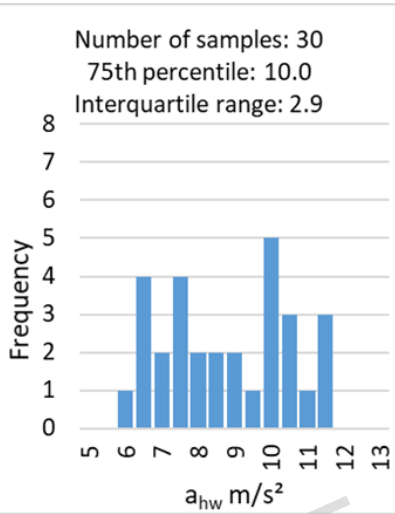
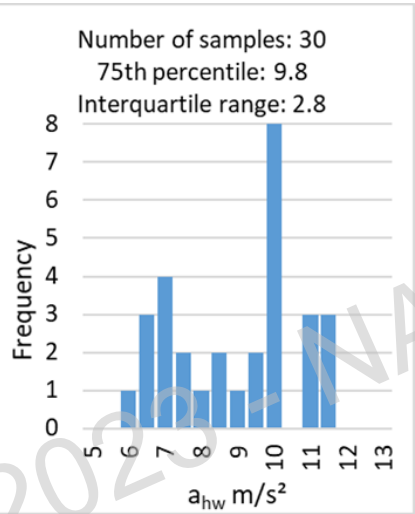
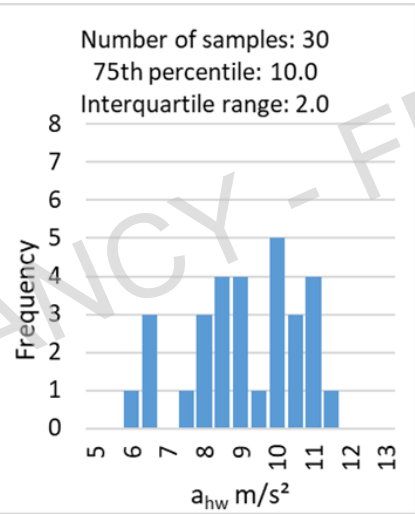
Comparison with real data sets

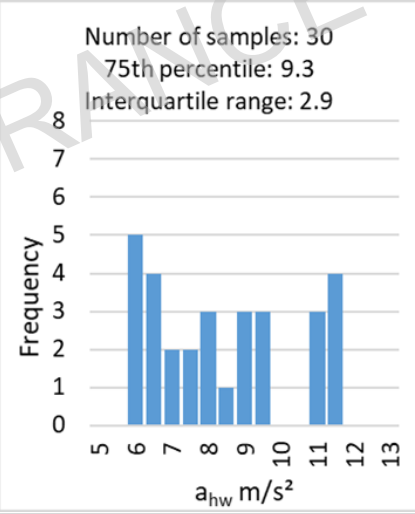
Simulated data



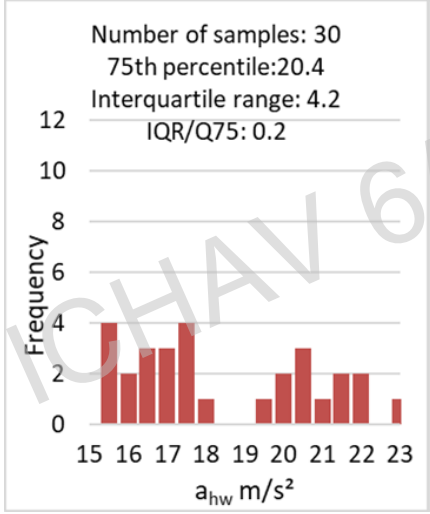


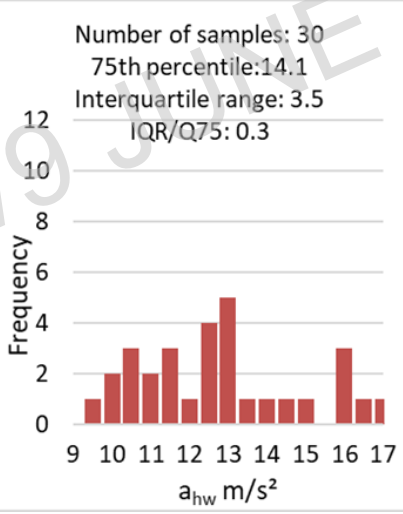


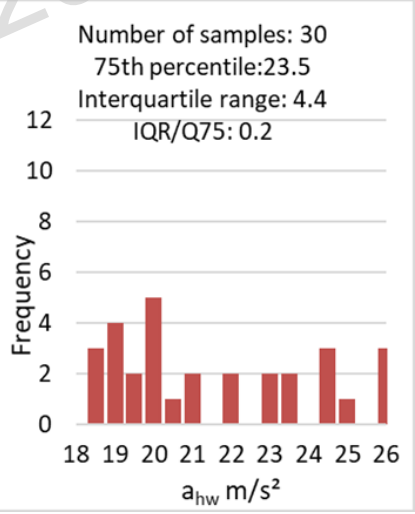


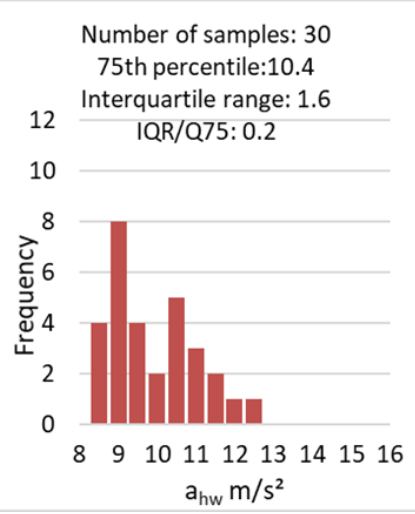


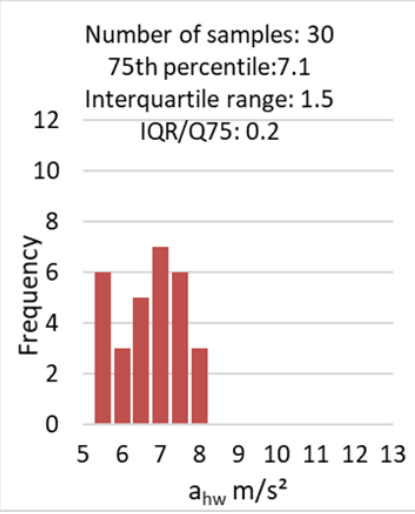
Real data











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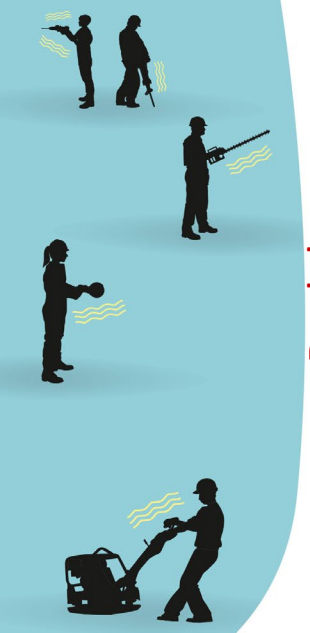

Conclusion 1

The distributions from real data and simulated data are comparable, so:

- Multiple measurements of HAV on power tools may be simulated by: uniform random distributions

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Monte Carlo Simulation

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Monte Carlo simulation

Generate data sets:

- Target 75th percentile value of 10 m/s²
- Sample numbers: 5 to 50 (step 1)
- IRQ/Q75: 0.1, 0.2, **0.3**, 0.4, 0.6
- Generate versions of each data set 1000 times

For each set, compute:

- Q75 value
- Error from target 75th percentile
- Distribution of errors within the 1000 repeats

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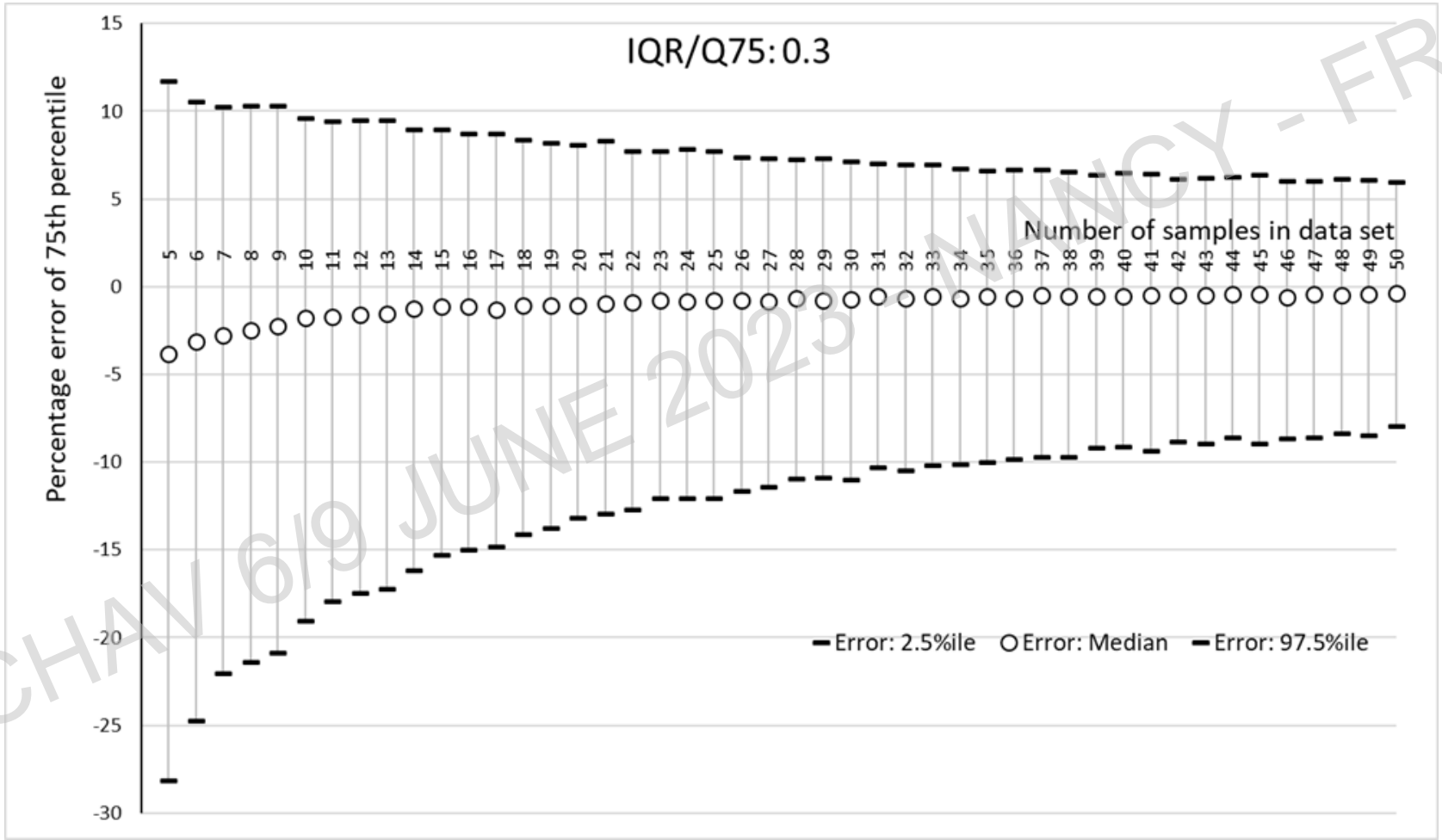
Distributions of 75th percentile errors



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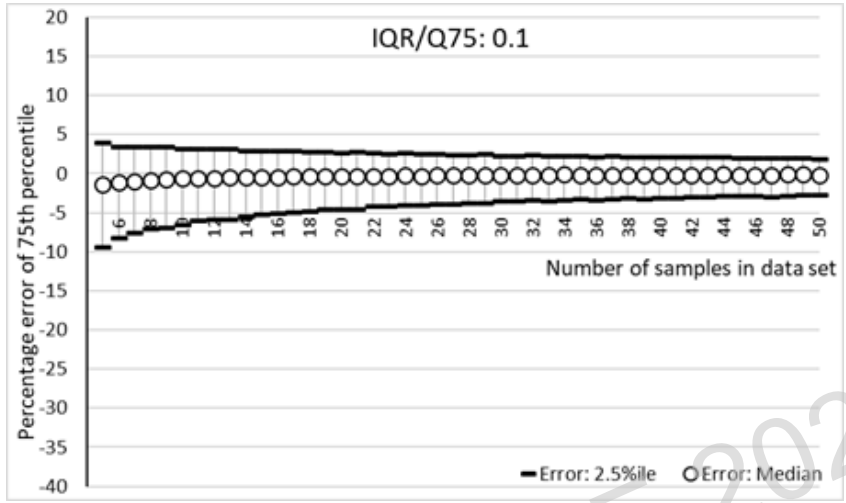
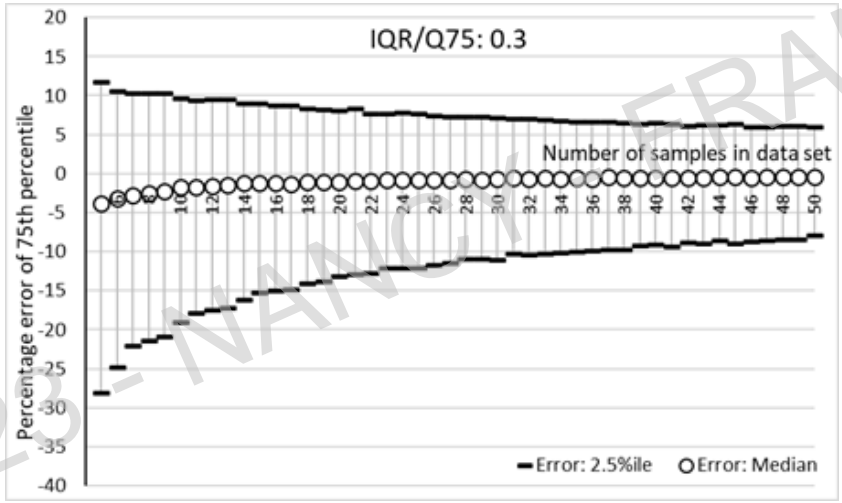
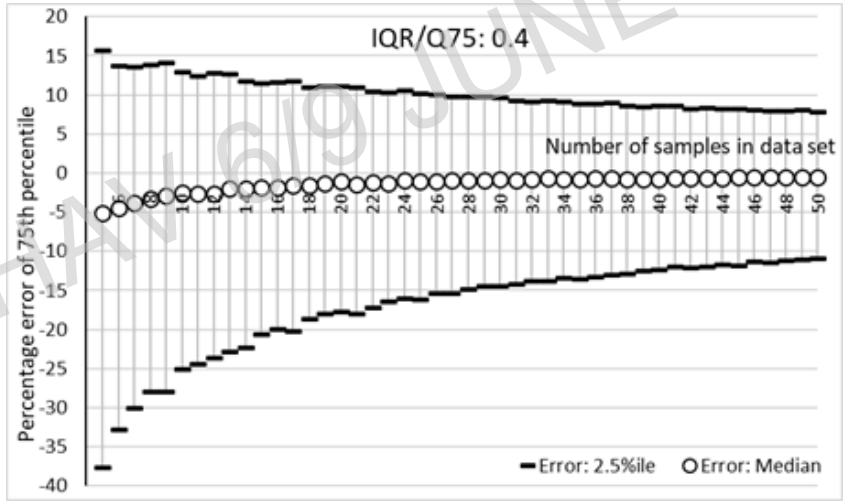
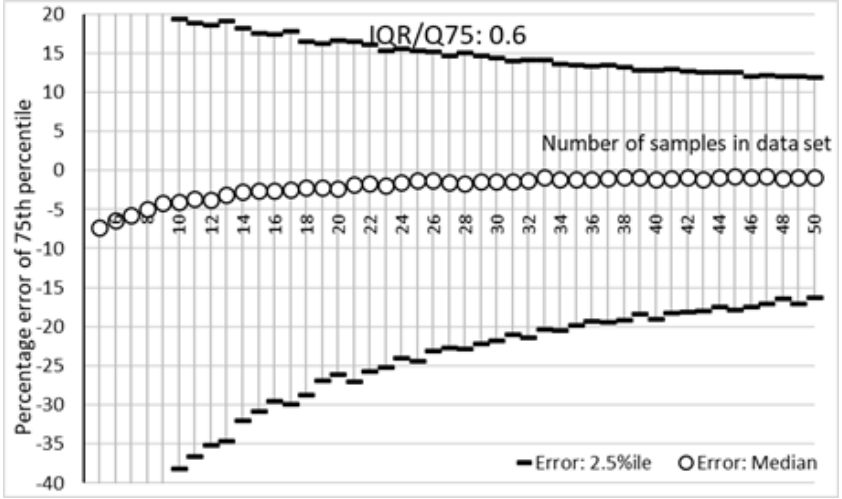
Distributions for different IQR/Q75 values









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Conclusions

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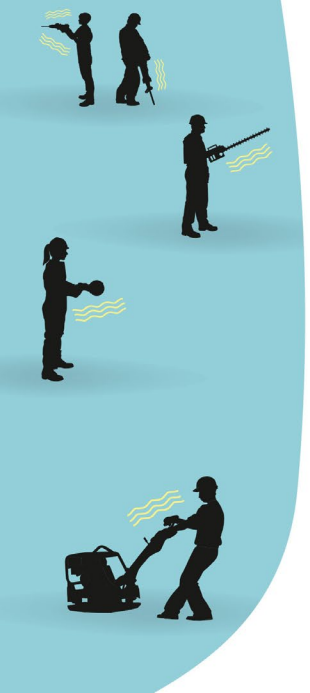
Conclusion 2 & 3

For an estimates with 95% confidence:

- For data with the median variability (IQR/Q75 = 0.3),
  35 measurements are required
  for an upper quartile value within **10%** of the true value.
- For data sets with greater variability (IQR/Q75 = 0.4 and 0.6),
  between **20 and 30 measurements** are required
  for an upper quartile value within **20%** of the true value.



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Conclusion 4

For practical measurements:

- Between 20 and 30 measurements is likely to achieve a reliable estimate of the true upper quartile value of real-use hand-arm vibration magnitude.

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The End

Thank You

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