Estimates of measurement uncertainty using data from participation in External Quality Assessment Schemes for trace elements in biological fluids

MARINA PATRIARCA, ISTITUTO SUPERIORE DI SANITÀ, ROME, ITALY &

VALERIA PATRIARCA - ISTITUTO SUPERIORE DI SANITÀ, ROME, ITALY

JOSIANE ARNAUD - CENTRE HOSPITALIER UNIVERSITARIE GRENOBLE LES ALPES, GRENOBLE, FRANCE

MONTSERRAT GONZÁLEZ ESTECHA - HOSPITAL CLÍNICO SAN CARLOS, MADRID, SPAIN
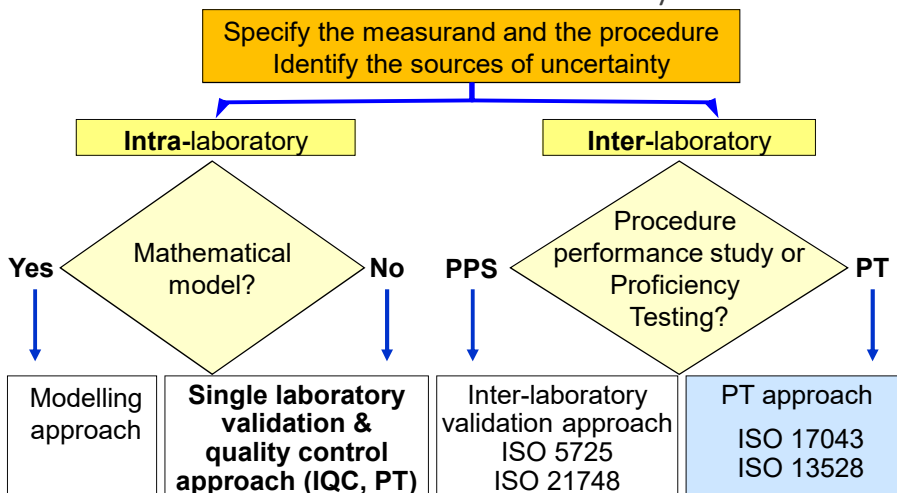
CHRIS HARRINGTON - ROYAL SURREY COUNTY HOSPITAL, GUILDFORD, UK

SAMANTHA SHEPHERD - THE ROYAL COLLEGE OF PATHOLOGISTS OF AUSTRALASIA QUALITY ASSURANCE PROGRAMS, ST LEONARDS, NSW, AUSTRALIA

MONTSERRAT VENTURA, MªCARMEN GONZÁLEZ - SPANISH SOCIETY OF LABORATORY MEDICINE, BARCELONA, SPAIN

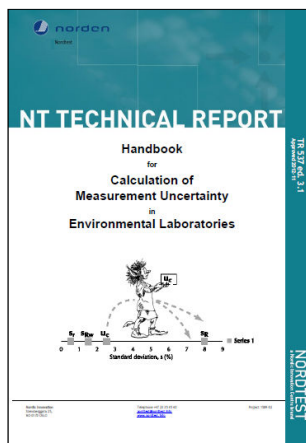**CAS WEYKAMP** - QUEEN BEATRIX HOSPITAL, WINTERSWIJK, THE NETHERLANDS

EURACHEM WORKSHOP ON PROFICIENCY TESTING IN ANALYTICAL CHEMISTRY, MICROBIOLOGY AND LABORATORY MEDICINE
PORTOROZ (SLOVENIA), 9 - 12 OCTOBER 2017

1

Approaches to the evaluation of measurement uncertainty*

**Specify the measurand and the procedure
Identify the sources of uncertainty**

Intra-laboratory

Inter-laboratory

Yes ← Mathematical model? → **No**

PPS ← Procedure performance study or Proficiency Testing? → **PT**

| Modelling approach | **Single laboratory validation & quality control approach (IQC, PT)** | Inter-laboratory validation approach ISO 5725 ISO 21748 | PT approach ISO 17043 ISO 13528 |

*Graph outline from: EUROLAB Technical Report No. 1/2007

www.eurolab.org.

EURACHEM WORKSHOP ON PROFICIENCY TESTING IN ANALYTICAL CHEMISTRY, MICROBIOLOGY AND LABORATORY MEDICINE
PORTOROZ (SLOVENIA), 9 - 12 OCTOBER 2017

2

The Nordtest approach main equations

$$u_{c} = \sqrt{u(R_{w})^{2} + u(bias)^{2}}$$

Within-laboratory reproducibility

Uncertainty of the estimate of the laboratory and the procedure bias

$$u(bias) = \sqrt{RMS_{bias}^{2} + u(Cref)^{2}}$$

Bias variability

Average uncertainty of the reference value

http://www.nordtest.info/index.php/technical-reports/item/handbook-for-calculation-of-measurement-uncertainty-in-environmental-laboratories-nt-tr-537-edition-3.html

---

Nordtest approach

ADVANTAGES	LIMITATIONS
Based on **real working data**	It requires: - a **large amount** of data - collected over a **period of time**
Assessment of bias **over a range of matrices / levels** (scope of the method)	Ideally **CRMs / reference measurements** should be used to estimate bias
Simplified approach, less rigorous statistics	"Rough" approach → **it overestimates MU**

PT items for MU estimate: pros / cons

Availability

Covering the range of concentrations / matrices

Closer to real samples

Limited cost

Assigned values often not traceable but
  when considerable experience exists, consensus values
  are a good estimate of reference values

In many areas of testing, most laboratories
participate in PT not more than once a year….!

EURACHEM WORKSHOP ON PROFICIENCY TESTING IN ANALYTICAL CHEMISTRY, MICROBIOLOGY AND LABORATORY MEDICINE
PORTOROZ (SLOVENIA), 9 - 12 OCTOBER 2017

5

Laboratory Medicine
External Quality Assessment Schemes

Typically:

• Covering the range of matrices / levels

• High frequency, e.g. once a month

• Estimates of precision included

Can this information be used by the
provider to estimate a participant's
measurement uncertainty with the
Nordtest approach?

EURACHEM WORKSHOP ON PROFICIENCY TESTING IN ANALYTICAL CHEMISTRY, MICROBIOLOGY AND LABORATORY MEDICINE
PORTOROZ (SLOVENIA), 9 - 12 OCTOBER 2017

6

EQA Schemes involved in this project

The Federate EQAS for trace elements in biological fluids

- A joint EQAS sharing the same PT items and database among 6 different countries (Australia, Belgium, France, Italy, Spain, The Netherlands)

UK TEQAS

- A UK-based EQAS for trace elements with world-wide participation

Both part of the Network of Organizers of EQAS
in Environmental and Occupational Laboratory Medicine
www.trace-elements.eu

Features of the Federate OELM EQAS (1)
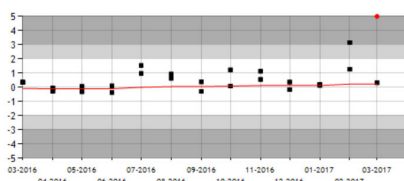
24 PT items, including 12 duplicates

Two PT items analysed each month in a cycle of 12 months

- Assigned values: robust means, x^*
- Uncertainties of assigned values calculated from the robust SD, s^* as described in ISO 13528
- z-scores against pre-set criteria

- Annual evaluation of laboratory intermediate precision based on differences between duplicates, excluding «outliers», i.e. data with |z-score| >5
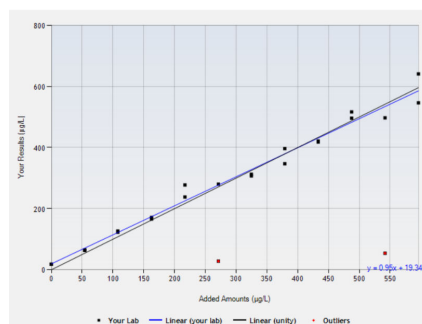
Features of the Federate OELM EQAS (2)

Performance score

Z-score	Performance score
≤1	3
>1 – 2	2
>2 – 3	1
>3	0
No result submitted	0

Performance score includes:

- «outliers», i.e. data with |z-score| >5

- not reported results

Cumulative Performance score

Analyte	Submissions		Performance	
	Your Lab	Max	Your Lab	Min Pass
Cd Blood	24	24	62	48
Co Blood	24	24	67	48
Cr Blood	24	24	62	48
Hg Blood	24	24	61	48
Mn Blood	24	24	61	48
Pb Blood	24	24	54	48

Example

EURACHEM WORKSHOP ON PROFICIENCY TESTING IN ANALYTICAL CHEMISTRY, MICROBIOLOGY AND LABORATORY MEDICINE PORTOROZ (SLOVENIA), 9 - 12 OCTOBER 2017

9

NT TECHNICAL REPORT

Handbook
for
Calculation of
Measurement Uncertainty
in
Environmental Laboratories
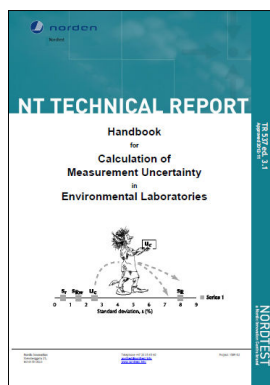
Preliminary assessment using only data from the Federate OELM EQAS

- Pb in blood
- Cycle: 2016-2017
- 102 participants
- Different analytical techniques: ETAAS, ICP-MS, FAAS
- Conc range: 20 – 600 µg/L

79 sets > 12 results, at least 3 pairs

Exclusions:

- «Outliers» (i.e. data with |z-score| >5).
  Where possible, obvious blunders (such as wrong units, transcription errors, decimal errors) corrected
- Data reported as «0»: excluded

EURACHEM WORKSHOP ON PROFICIENCY TESTING IN ANALYTICAL CHEMISTRY, MICROBIOLOGY AND LABORATORY MEDICINE PORTOROZ (SLOVENIA), 9 - 12 OCTOBER 2017

10

Participants' measurement uncertainty estimated from their EQAS data: Pb in blood, 2016-2017

EURACHEM WORKSHOP ON PROFICIENCY TESTING IN ANALYTICAL CHEMISTRY, MICROBIOLOGY AND LABORATORY MEDICINE
PORTOROZ (SLOVENIA), 9 - 12 OCTOBER 2017
11

Participants' measurement uncertainty estimated from their EQAS data: Pb in blood, 2016-2017

Average s*% = 8.8%

EURACHEM WORKSHOP ON PROFICIENCY TESTING IN ANALYTICAL CHEMISTRY, MICROBIOLOGY AND LABORATORY MEDICINE
PORTOROZ (SLOVENIA), 9 - 12 OCTOBER 2017
12
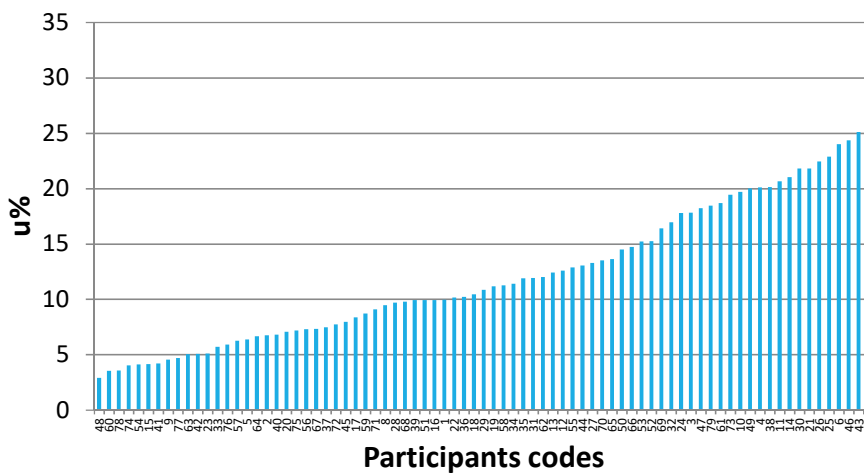
Participants' MU vs Cumulative
Performance Score: Pb in blood, 2016-2017

Participants' MU vs Cumulative
Performance Score: Pb in blood, 2016-2017

$y = -0,3639x + 31,448$
$R^2 = 0,6113$
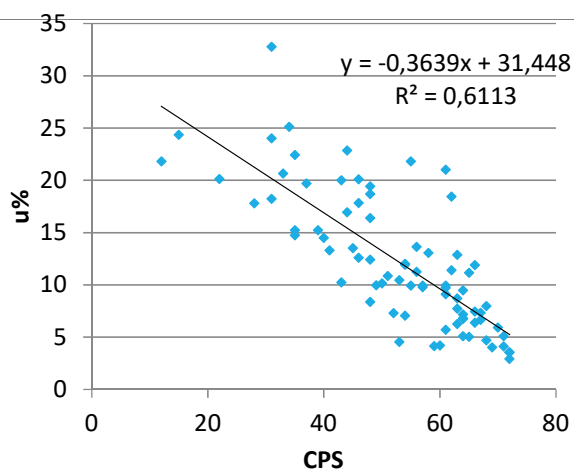
Are these MU estimates plausible?

Use of PT to check measurement uncertainties

The ζ (zeta)-score can help to check the plausibility of the laboratory's measurement uncertainty estimate. It is calculated as follows:
where x is the laboratory's result, X the assigned value, and their

$$\zeta = \frac{(x - X)}{\sqrt{u_x^2 + u_X^2}}$$

Evaluation:
$0 < |z| \leq 2$: satisfactory
$2 < |z| \leq 3$: *questionable*
$\quad |z| > 3$: unsatisfactory

respective standard uncertainties (u_x and u_X).

From the Eurachem leaflet
«How can proficiency testing help my laboratory?»

Eurachem
A FOCUS FOR
ANALYTICAL CHEMISTRY
IN EUROPE

EURACHEM WORKSHOP ON PROFICIENCY TESTING IN ANALYTICAL CHEMISTRY, MICROBIOLOGY AND LABORATORY MEDICINE
PORTOROZ (SLOVENIA), 9 - 12 OCTOBER 2017   15

Cycle 2017-2018: 76 labs, 12 PT items, 6 months, 867 results

3,4% ouside ±2

EURACHEM WORKSHOP ON PROFICIENCY TESTING IN
ANALYTICAL CHEMISTRY, MICROBIOLOGY AND
LABORATORY MEDICINE PORTOROZ (SLOVENIA), 9 - 12
OCTOBER 2017   16

Conclusions

- It looks promising!

- It is based on <u>independent tests</u> of the performance of the laboratory

- It is «taylored» to the individual participant!

- It requires no additional work from participants!

Application over wide ranges must consider constant vs proportional MU

The skilful assistance of Irene de Graaf
is gratefully acknowledged

EURACHEM WORKSHOP ON PROFICIENCY TESTING IN ANALYTICAL CHEMISTRY, MICROBIOLOGY AND LABORATORY MEDICINE
PORTOROZ (SLOVENIA), 9 - 12 OCTOBER 2017

17