HBM4EU science and policy for a healthy future

HORIZON2020 Programme
Contract No. 733032 HBM4EU

REPORT OF THE WP9 ICI

Round 04/2019

Chromium in urine

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Appendices

1 Summary

Within the framework of the HBM4EU project, an Inter-Laboratory Comparison Investigation (ICI) was organized and conducted for the analysis of chromium in urine.

The study was performed from October 2019 to December 2019.

In total, 46 laboratories were invited for this fourth round, of which 19 laboratories from 13 countries registered.

The participation in this ICI was satisfactory; 17 out of 19 laboratories (90%) submitted their results.

In November 2019, two different test samples consisting of 5 mL urine spiked with chromium at two different concentrations (Cr_{low}, Cr_{high}), one of each concentration, were prepared, and one sample of each concentration was sent to the participating laboratories for analysis.

Homogeneity and stability assessment of the control materials confirmed that the materials were adequately homogeneous and stable.

Laboratory results were rated using Z-scores in accordance with ISO 13528 and ISO 17043. The standard deviation for proficiency assessment (also called target standard deviation) was set at FFP = 25%, as described in 5.3.

The evaluation of Cr_{low} and Cr_{high} showed that 94% of the results were satisfactory (**Table 1**).

Table 1 Overview of results for Chromium in urine in 4th ICI

Number of laboratories with respective results for chromium in urine in 4th ICI				
biomarker	**assigned value**	**Satisfactory** (|Z-score| ≤2)	**questionable** (2<|Z-score|<3)	**unsatisfactory** (|Z-score|>3)
Cr_{low}	**3.066 ng/mL**	**16 (94%)**	**0**	**1 (6%)**
Cr_{high}	**10.614 ng/mL**	**16 (94%)**	**0**	**1 (6%)**

2 Introduction

Inter-Laboratory Comparison Investigations (ICI) and External Quality Assurance Schemes (EQUAS) are tools to assess the proficiency of laboratories, and the comparability and reliability of analytical methods. Participation in ICI / EQUAS forms an integral part of quality control, in addition to initial and ongoing in-house method validation.

This ICI study has been organised within the frame of HBM4EU as part of the Quality Assurance program for biomonitoring analyses. Within HBM4EU, participation in ICI/EQUAS exercises is mandatory for laboratories that will analyse HBM4EU samples.

This report describes the 4th round of proficiency testing for chromium in urine, which was organised by the Institute and Outpatient Clinic of Occupational, Social and Environmental Medicine (IPASUM) at Friedrich-Alexander University of Erlangen-Nuremberg.

2.1 Confidentiality

In this report, the identity of the participants and the information provided by them is treated as confidential. However, lab codes of the participants will be disclosed to the HBM-QAU for performance assessment.

3 Control material

3.1 Preparation of control material

For control material, surrogate material was used. It consists of human urine with sodium azide. The stock solution (Chromium ICP standard, ammonium dichromate in H_2O, 1000 mg/L, J.T.Baker) was diluted into two different concentrations and the addition to the native control material resulted in the intended concentration in control material (Cr_{low}, Cr_{high}). The two spiked control materials were aliquoted (5 mL each) into tubes with caps (82x13 mm, polypropylene, Sarstedt). The tubes were stored in a freezer (≤ -18 °C) until transportation. The two different concentrations (Cr_{low}, Cr_{high}) were measured using ICP-MS (see analysis method in **Appendix 5**).

3.2 Homogeneity of control material

Ten tubes of each concentration of the control material (Cr_{low}, Cr_{high}) were randomly selected from the freezer (≤ -18 °C). The thawed samples were re-homogenised by vortex shaking and analysed in duplicate using ICP-MS (analysis method see **Appendix 5**). The homogeneity was evaluated according to ISO 13528:2015, Fearn et al [2001] and Thompson [2000]. The results are presented in **Appendix 1**. The conclusion is that no outliers are detected, homogeneity is adequate and the method is suitable.

3.3 Stability of control material

On the day of preparation of the control materials, six randomly selected test samples of Cr_{low} and six randomly selected test samples of Cr_{high} were stored at -80 °C. The assumption is that under these conditions, the biomarker (Cr) is stable in urine. On the last day of the deadline for submission of results by the participants (December 4, 2019), six test samples of each level (stored at -80 °C) and six samples of each level (stored at -18 °C) were thawed and re-homogenised by vortex shaking. Next, all samples were analysed using ICP-MS (analysis method see **Appendix 5**). The stability was evaluated according to HBM4EU-SOP-QA-002 and using the Excel sheet “HBM4EU ICI-EQUAS stability test CM v1”. The results are presented in **Appendix 2**. No consequential instabilities and no statistical differences were detected.

4 Organisational details

4.1 Participants

A list of 46 candidate laboratories from different countries eligible for the analysis of chromium had been compiled by the Work Package (WP) Task 9.2 leaders and made available to the institution organizing the respective ICI.
Invitation letters were sent by e-mail to all 46 candidate laboratories on October 21, 2019 (see **Appendix 3**). It was indicated that participation would be free of charge and that those who subscribed to the ICI would receive a kit containing the test materials needed for analysis. The condition for participation was that the test results had to be submitted within the stipulated deadline (December 4, 2019).
Nineteen laboratories (41%) from 13 countries out of the 46 laboratories in the candidate list indicated their interest in participating in this ICI and sent their registration forms to IPASUM with their agreement to abide by the conditions for participation. These laboratories received an individual laboratory code to report their measurement results (see **Appendix 8**).

17 of the 19 potential participants (90%) performed the assays and submitted their results. All participants reported their results within the stipulated deadline.

4.2 Dispatch and instructions

Test materials were dispatched to the participants under ambient conditions on November 6, 2019. Each participant received two test samples spiked with the biomarker at two levels, one of each concentration. Each sample consisted of approximately 5 mL urine.
Moreover, a letter with instructions on sample handling (instruction letter, see **Appendix 4**), a sample receipt form to be sent back to IPASUM upon receipt of the test material as well as a result submission form and a method information form were sent to the participants by e-mail. The latter form was used to extract relevant information related to the analytical method used for quantification.
Participants were asked to perform a single analysis of each sample using the same procedure as will be used for analysis of samples in the frame of HMB4EU and to report results following the instructions given.

4.3 Deviations from ICI/EQUAS SOPs

The 4th ICI for Chromium in urine followed the HBM4EU-QA-SOPs (version 2). There were no deviations from these SOPs.

5 Data evaluation

5.1 False negatives and <LOQ

Classification of false positives and biomarkers reported as "<LOQ-value" or "not detected" (ND) is described in HBM4EU-SOP-QA-003. In this EQUAS there were no false positives and no ND. Therefore, no further description is given here.

5.2 Assigned value

For ICI studies, the consensus value is used as assigned value and calculated as described in SOP HBM4EU-SOP-QA-003. In brief, the consensus value and its uncertainty were calculated from the results submitted by the participants using robust statistics to minimize the influence of outliers.

5.3 Target standard deviation

For calculation of the Z-scores, a fit-for-purpose relative target standard deviation (FFP-RSD_R) of 25% of the assigned value was used as target standard deviation. This was the default indicated in HBM4EU-SOP-QA-003 and considered appropriate based on the outcome of the 1st round.

5.4 ICI standard deviation

To gain insight into the actual inter-laboratory variability of the biomarker analysis in this study, the robust relative standard deviation (RSD_R) was calculated based on the participants' results, as described in HBM4EU-SOP-QA-003.

5.5 Z-scores

Z-scores were calculated according to SOP HBM4EU-SOP-QA-003.

In accordance with ISO 13528 and ISO 17043 and the deliverable D 9.4 "*The Quality Assurance/Quality Control Scheme in the HBM4EU project"*, Z-scores are classified as presented in **Table 2.**

Table 2 Classification of Z-scores

$\lvert Z\rvert \le 2$	satisfactory
$2 < \lvert Z\rvert < 3$	questionable
$\lvert Z\rvert \ge 3$	unsatisfactory

6 Results and discussion

6.1 Results submitted by participants

In total, 19 laboratories from 13 countries agreed to participate in this study. Not all participants were able to meet the stipulated deadline, so that in the end, 17 out of 19 participants (90%) submitted their results. Laboratories were also asked to provide LOQs.

Appendix 8 gives an overview of results and LOQs submitted by the participants as well as reasons for delayed submission.

Results indicated as `not detected´ (ND, see **Appendix 8)**:

For **Cr_{low}** and **Cr_{high}**, no laboratory indicated ND.

False positive results: No participant detected a false positive in **Cr_{low}** and **Cr_{high}**.

Methods:

In all cases the samples were analysed by ICP-MS. For sample preparation, most laboratories used no digestion while the others used acid digestion. Almost all participating laboratories used a single quad as detection system, the rest used a triple. As internal standard, the majority of participating laboratories applied germanium, yttrium or rhodium and for calibration, most candidates used an external calibrant (solvent-based), followed by standard addition and external calibrant (matrix-based).

6.2 Assigned values and (target) standard deviations

The assigned value and its uncertainty (u), the robust relative standard deviation of the participant's data (study RSD_R), and the fit-for-purpose (FFP) target standard deviation for each of the control materials are included in **Appendix 6**.

6.3 Assessment of laboratory performance

Z-scores were calculated and graphical representations of the Z-scores for Cr_{low} and Cr_{high} are provided in **Appendix 7**.

Seventeen laboratories out of 19 registered candidate laboratories reported results. In **Cr_{low}** and **Cr_{high}**, 94% of the laboratories achieved satisfactory Z-scores.

6.4 Conclusions and recommendations

The overall participation in the HBM4EU ICI Round 4 was successful. Nineteen laboratories out of the 46 laboratories (41%) in the candidate list confirmed their participation in the ICI. This ICI was specifically aimed at participants who want to qualify for the occupational chromium study. Consequently, successful participation in two ICI studies will lead to approval and a certificate being issued for the occupational exposure range only.

Seventeen of the 19 registered candidate laboratories reported results, representing a participation rate of 90%.

Regarding the quantification of chromium in urine, 94% of the participants achieved satisfactory results in **Cr_{low}** and **Cr_{high}**.

The participant with unsatisfactory results is recommended to do a root cause analysis to find the reason for the deviating results, and seek assistance from HBM4EU expert laboratories if needed.

A direct comparison of the overall performance of the laboratories with that of the previous rounds is not entirely possible, because there were some laboratories from the previous rounds that did not participate in this round.

The percentage of satisfactory Z-scores at both levels was 100% in the first and second round, in the third round it was 100% for **Cr_{high}** and 92% for **Cr_{low}** and in this round it was 94% at both levels.

Table 3 below gives an overview of the performance of the individual laboratories in this round for chromium in urine.

Table 3 Performance of the candidate laboratories for chromium in urine

Lab code	LOQ [ng/mL]	Cr_{low}	Cr_{high}
QR/101	1.000	**satisfactory**	**satisfactory**
QR/111	0.255	**satisfactory**	**satisfactory**
QR/115	0.600	**satisfactory**	**satisfactory**
QR/118	0.152	**satisfactory**	**satisfactory**
QR/119	0.200	**unsatisfactory**	**unsatisfactory**
QR/129	0.090	**satisfactory**	**satisfactory**
QR/130	0.150	**satisfactory**	**satisfactory**
QR/143	0.180	**satisfactory**	**satisfactory**
QR/203	0.290	**satisfactory**	**satisfactory**
QR/205	0.010	**satisfactory**	**satisfactory**
QR/206	0.200	**satisfactory**	**satisfactory**
QR/211	0.100	**satisfactory**	**satisfactory**
QR/212	0.100	**satisfactory**	**satisfactory**
QR/224	0.050	**satisfactory**	**satisfactory**
QR/225	0.050	**satisfactory**	**satisfactory**
QR/226	1.000	**satisfactory**	**satisfactory**
QR/301	-	**satisfactory**	**satisfactory**

7 References

[1] Analytical Methods Committee, 1989a, Robust statistics - How not to reject outliers Part 1. Basic concepts, Analyst, 114, 1693-1697.

[2] Analytical Methods Committee, 1989b, Robust statistics - How not to reject outliers Part 2. Interlaboratory trials, Analyst, 114, 1699-1702

[3] HBM4EU-SOP-QA-001 "Organisation of Interlaboratory Comparison Investigations (ICI) and External Quality Assurance Schemes (EQUAS) of interlaboratory studies"

[4] HBM4EU-SOP-QA-002 "Preparation of test materials for ICI / EQUAS"

[5] HBM4EU-SOP-QA-003 "Evaluation of ICI / EQUAS results"

[6] HBM4EU-SOP-QA-004 "Reporting of ICI / EQUAS studies"

[7] ISO/IEC 17043:2010, Conformity assessment – General requirements for proficiency testing

[8] ISO 13528, 2015, Statistical methods for use in proficiency testing by interlaboratory comparison.

[9] Official Methods of Analysis Program Manual, 2002, Appendix D: Guidelines for Collaborative Study Procedures to Validate Characteristics of a Method of Analysis. Association of Analytical Communities International. http://www.aoac.org/vmeth/Manual_Part_6.pdf.

[10] Thompson, M., 2000, Recent trends in inter-laboratory precision at ppb and sub-ppb concentrations in relation to fitness for purpose criteria in proficiency testing, Analyst, 125, 385-386.

[11] Thompson M., Ellison R. and Wood, R., 2006, The International Harmonized Protocol for the Proficiency Testing of Analytical Chemistry Laboratories, Pure Appl. Chem, 78(1), 145-196.

Appendix 1. Homogeneity data

Homogeneity

Version HBM4EU v1

Control material: **urine**

Analyte: **Chromium**

Preparation of control material: **low**

10 randomly chosen test samples, analysed in duplicate

Target standard deviation:
Fit-for-purpose RSD **FFP** (25% is default value)
if you want to use Horwitz/Thompson,
then delete FFP from cell H5

[1] ISO 13528:2005
[2] Fearn, T. and M. Thompson, 2001, A New Test for 'Sufficient homogeneity', Analyst, 126, 1414-1417
[3] Thompson M., 2000, Recent trends in inter-laboratory precision at ppb and sub-ppb concentrations in relation to fitness for purpose criteria in proficiency testing, Analyst, 125, 385-386

	replicate 1	replicate 2	x_t	w_t	w_t^2	$(x_t - \bar{x})^2$
1	2.948	2.859	2.904	0.089	0.008	0.003
2	2.807	2.808	2.808	-0.001	0.000	0.002
3	2.817	2.841	2.829	-0.024	0.001	0.000
4	2.892	2.854	2.873	0.038	0.001	0.001
5	2.826	2.791	2.809	0.035	0.001	0.001
6	2.774	2.861	2.818	-0.087	0.008	0.001
7	2.900	2.930	2.915	-0.030	0.001	0.005
8	2.878	2.913	2.896	-0.035	0.001	0.002
9	2.783	2.828	2.806	-0.045	0.002	0.002
10	2.808	2.818	2.813	-0.010	0.000	0.001
				Σ =	0.023	0.018

Lowest:	2.774	µg/kg
Highest	2.948	µg/kg
Grand mean ($\bar{x}$):	2.847	µg/kg
Stdev:	0.050	µg/kg
VC%:	1.8%	µg/kg

Outliers: Cochran's test

$C = w^2_{max} / \Sigma w_t^2$

--> C = 0.345
--> Ccrit= 0.602

C < Ccrit → No outliers detected

Horwitz [3]:

Mean > 120 ppb: CV=2(1-½ log c)		Mean < 120 ppb: σ = 0,22c		FFP (fit-for-purpose)	
RSD% =	38.66	RSD% =	22	RSD% =	25
σ_H =	1.101	σ_H =	0.626	σ_H =	0.712

σ_H used: 0.712

Homogeniteit [1]:

s_x =	0.045	
s_w =	0.034	(within sample standard deviation)
s_s =	0.038	(between sample standard deviation)
critical=	0.214	

s_s < critical? **→ ACCEPT: Homogeneity adequate**
s_w < 0.5*σ_H? **→ ACCEPT: Method suited**

Appendix 1 Homogeneity data (continued)

Homogeneity

Version HBM4EU v1

Control material: urine

Analyte: Chromium

Preparation of control material: high

10 randomly chosen test samples, analysed in duplicate

Target standard deviation:
Fit-for-purpose RSD FFP (25% is default value)
if you want to use Horwitz/Thompson,
then delete FFP from cell H5

[1] ISO 13528:2005
[2] Fearn, T. and M. Thompson, 2001, A New Test for 'Sufficient homogeneity', Analyst, 126, 1414-1417
[3] Thompson M., 2000, Recent trends in inter-laboratory precision at ppb and sub-ppb concentrations in relation to fitness for purpose criteria in proficiency testing, Analyst, 125, 385-386

	replicate 1	replicate 2	x_t	w_t	w_t^2	$(x_t - \bar{x})^2$
1	9.906	10.080	9.993	-0.174	0.030	0.000
2	9.837	10.070	9.954	-0.233	0.054	0.003
3	9.875	10.170	10.023	-0.295	0.087	0.000
4	10.000	10.190	10.095	-0.190	0.036	0.008
5	9.967	10.150	10.059	-0.183	0.033	0.003
6	9.934	10.080	10.007	-0.146	0.021	0.000
7	9.841	10.210	10.026	-0.369	0.136	0.000
8	10.040	10.380	10.210	-0.340	0.116	0.041
9	9.698	9.749	9.724	-0.051	0.003	0.080
10	9.803	10.160	9.982	-0.357	0.127	0.001
				Σ =	0.644	0.136

Lowest:	9.698	µg/kg
Highest	10.380	µg/kg
Grand mean ($\bar{x}$):	10.007	µg/kg
Stdev:	0.177	µg/kg
VC%:	1.8%	µg/kg

Outliers: Cochran's test

$C = w^2_{max} / \Sigma w_t^2$

--> C = 0.211
--> Ccrit= 0.602 C < Ccrit → No outliers detected

Horwitz [3]:

Mean > 120 ppb: CV=2(1-½ log c)		Mean < 120 ppb: σ = 0,22c		FFP (fit-for-purpose)	
RSD% =	32.00	RSD% =	22	RSD% =	25
σ_H =	3.202	σ_H =	2.202	σ_H =	2.502

σ_H used: 2.502

Homogeniteit [1]:

s_x =	0.123	
s_w =	0.179	(within sample standard deviation)
s_s =	0.000	(between sample standard deviation)
critical=	0.751	

s_s < critical? → ACCEPT: Homogeneity adequate
s_w < 0.5*σ_H? → ACCEPT: Method suited

Appendix 2 Stability data

HBM4EU ICI-EQUAS stability test CM v1

Stability test in frame of ICI-EQUAS

Material: **Cr (urine)**
Storage: minus 80 °C minus 18 °C

Biomarker **Chromium low**

	t=0 (storage)	t=a (analysis)
dates:	30.09.2019	05.12.2019
values:	2.98	3.10
	2.99	3.02
	3.07	3.26
	3.12	3.02
	2.94	2.98
	2.99	3.07
number=	6	6
average=	3.015	3.075
std dev=	0.067	0.100

analysis date	time (days)	µg/L	n	std dev
30.09.2019	0	3.015	6	0.067
05.12.2019	66	3.075	6	0.100
x0-xa=	**-0.06**			

test 'consequential instability	Horwitz/Thompson	**Fit-for-purpose (FFP)**
xav-yav =<0,3σH		
σH=	0.663	0.75375
0,3*σH=	0.199	0.226125
x0-xa<0,3*σH?	**No consequential instability detected**	**No consequential instability detected**

test 'significant difference':	
F=	2.26
Fcrit=	5.05
Significant difference?	**No significant difference in std detected**
sed^2=	0.08
n=	10
std difference=	0.05
t=	1.22
t-crit=	2.23
Significant difference?	**No statistic instability detected**

HBM4EU ICI-EQUAS stability test CM v1

Stability test in frame of ICI-EQUAS

Material: **Cr (urine)**
Storage: minus 80 °C minus 18 °C

Biomarker **Chromium high**

	t=0 (opslag)	t=a (analyse)
dates:	30.09.2019	05.12.2019
values:	10.360	10.440
	10.480	10.550
	10.610	10.510
	10.410	10.620
	10.450	10.430
	10.270	10.490
number=	6	6
average=	10.430	10.507
std dev=	0.115	0.071

analysis date	time (days)	µg/L	n	std dev
30.09.2019	0	10.430	6	0.115
05.12.2019	66	10.507	6	0.071
x0-xa=	**-0.08**			

test 'consequential instability	Horwitz/Thompson	**Fit-for-purpose (FFP)**
xgem-ygem =<0,3σH		
σH=	2.295	2.6075
0,3*σH=	0.688	0.78225
x0-xa<0,3*σH?	**No consequential instability detected**	**No consequential instability detected**

test 'significant difference':	
F=	2.61
Fcrit=	5.05
Significant difference?	**No significant difference in std detected**
sed^2=	0.10
n=	10
std difference=	0.06
t=	1.39
t-crit=	2.23
Significant difference?	**No statistic instability detected**

Appendix 3 Copy of letter of invitation

HBM4EU: Announcement / invitation to participate in ICI study Cr/Round 4

Title of ICI: Chromium in blood, serum and urine

Dear Colleagues,

within the frame of HBM4EU the

Institute and Outpatient Clinic of Occupational, Social and Environmental Medicine
Friedrich-Alexander University Erlangen-Nuremberg
Henkestr. 9-11
91054 Erlangen
Germany

announces the 4th ICI round for the determination of chromium in blood, serum and urine. The aim of ICI exercises is to provide laboratories with an assessment of their analytical performance and reliability of their data in comparison with other laboratories. This will aid in the quality improvement of analysis in human biomonitoring at each of the laboratories.

Test samples
The matrices will be blood, serum and urine, respectively. Accordingly, the participants will receive:

- 2 different materials of blood (1 sample of 3 mL each) for determination of chromium in blood and/or
- 2 different materials of serum (1 sample of 3 mL each) for determination of chromium in serum and/or
- 2 different materials of urine (1 sample of 5 mL each) for determination of chromium in urine

Target biomarkers

The biomarker potentially present in the test samples is chromium.

This ICI is specifically aimed at participants who want to qualify for the occupational chromium study. Consequently, successful participation in the ICI studies will lead to approval and a certificate being issued for the occupational exposure range only.

With regard to the conditions and specifications of the occupational study, we expect participants of this ICI to use suitable analytical methods to obtain an **LOQ < 1 µg/L.**

We would appreciate the participation of all laboratories in this ICI irrespective of their participation/approval in the previous ICIs.

Calendar:

Registration deadline	November 01, 2019 (we would be pleased to receive your feedback as soon as possible)
Distribution of test samples (projected)	November 04, 2019
Deadline for submission of results (projected)	December 02, 2019

Registration

For registration, please find attached a registration form each for chromium in blood, in serum and in urine. Please send them back to us by mail in case you want to register.
Upon registration, the participant will receive a lab-code to be used for submission of results.

Fee

For partners and linked-third parties of HBM4EU, participation is free of charge. Please note that the participant is responsible for custom clearance and associated costs if applicable.

Confidentiality:

All laboratory-specific information will be treated confidentially, and will never be disclosed to third parties (government, accreditation bodies) except the HBM4EU QAU, without permission of the laboratory

Contact information organiser:

Coordinators:

- Prof. Dr. Thomas Göen
- Stefanie Nübler
- Moritz Schäfer
- Karin H. A. Zarrabi

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Appendix 4 Copy of letter/instructions sent together with test samples

HBM4EU: Instruction letter ICI study Cr in urine/Round 4

Title of ICI: Chromium in urine

Dear participant,

Thank you for participation in HBM4EU ICI study Cr in urine/Round 4 for the determination of Chromium in urine.

You will receive a parcel containing 2 test samples spiked with the biomarker at 2 levels, 1 of each concentration. Each sample consists of approximately 5 mL urine.

The parcel will be shipped on November 6, 2019 under ambient conditions.

Instructions:

- Upon receipt, please check the content for any damage/leaking of the containers, complete the sample receipt form and return it to the organiser.
- Store the test samples under frozen (-18°C) conditions until analysis.
- Analyse the samples for the biomarkers indicated in the invitation letter ref/ 21.10.2019.
- Thaw the samples and re-homogenise them according to your own procedure.
- Analyse the samples using the same procedure as will be used for analysis of samples in the frame of HBM4EU.
- Carry out a single analysis for each sample.
- For submission of results and method information use the forms provided.
- The deadline for submission of analysis results and method details is **December 4, 2019**.

If you have any questions or need any assistance, please contact:

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Prof. Dr. Thomas Göen (for the ICI organisers)

Appendix 5 ICP-MS method information IPASUM

HBM4EU: Method information form for participation in ICI / EQUAS study Cr/Round 4

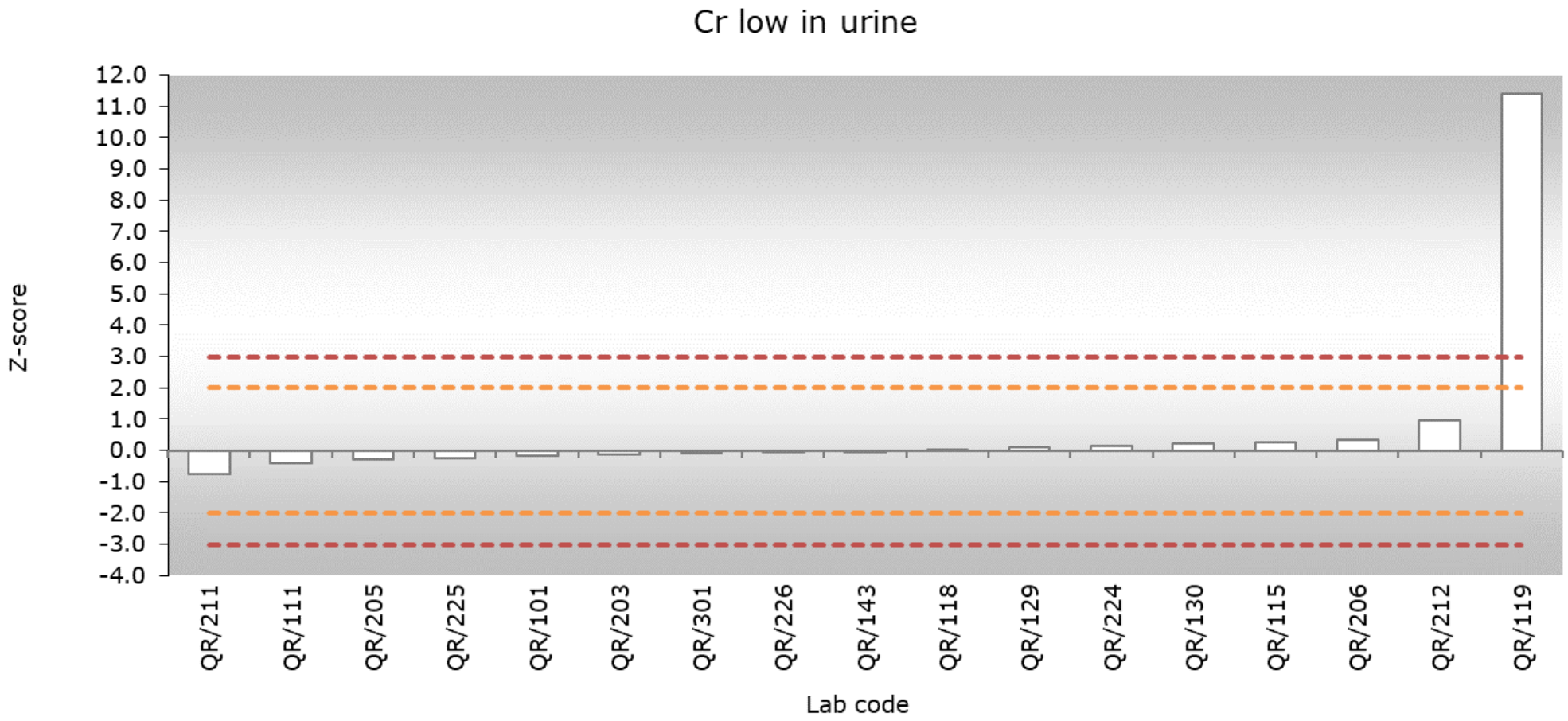
Title of ICI: Chromium in urine

Laboratory code	**IPASUM Erlangen - Germany**
ISO17025 accredited	**no**
SAMPLE PREPARATION	
amount sample	**0.4 mL**
Extraction	**no**
- pH adjustment	
- LLE; solvent(s) / time / shaking	
- SPE; material	
Digestion	**no**
INSTRUMENTAL ANALYSIS	
AAS	**no**
Wavelength	
Background compensation	
Matrix modifier	
Dilution factor	
Other remarks	
ICP	**Yes (ICP-MS Perkin Elmer)**
Dilution	**1:10 with H_20 and HNO_3**
Nebulizer	**glass**
Reagent gas	**Argon**
Masses monitored	**Cr^{52}**
Detection	
MS	**single quad**
OES	
Quantification	
Use of internal standard (IS)	**yes (Rh^{103})**
- response normalised to IS	**yes**
Calibration	**external calibrant (matrix-based)**
	Multi-level
Correction for recovery	**no**
Identification criteria used	
- ion ratio tolerance	**% relative**
- other	**-**

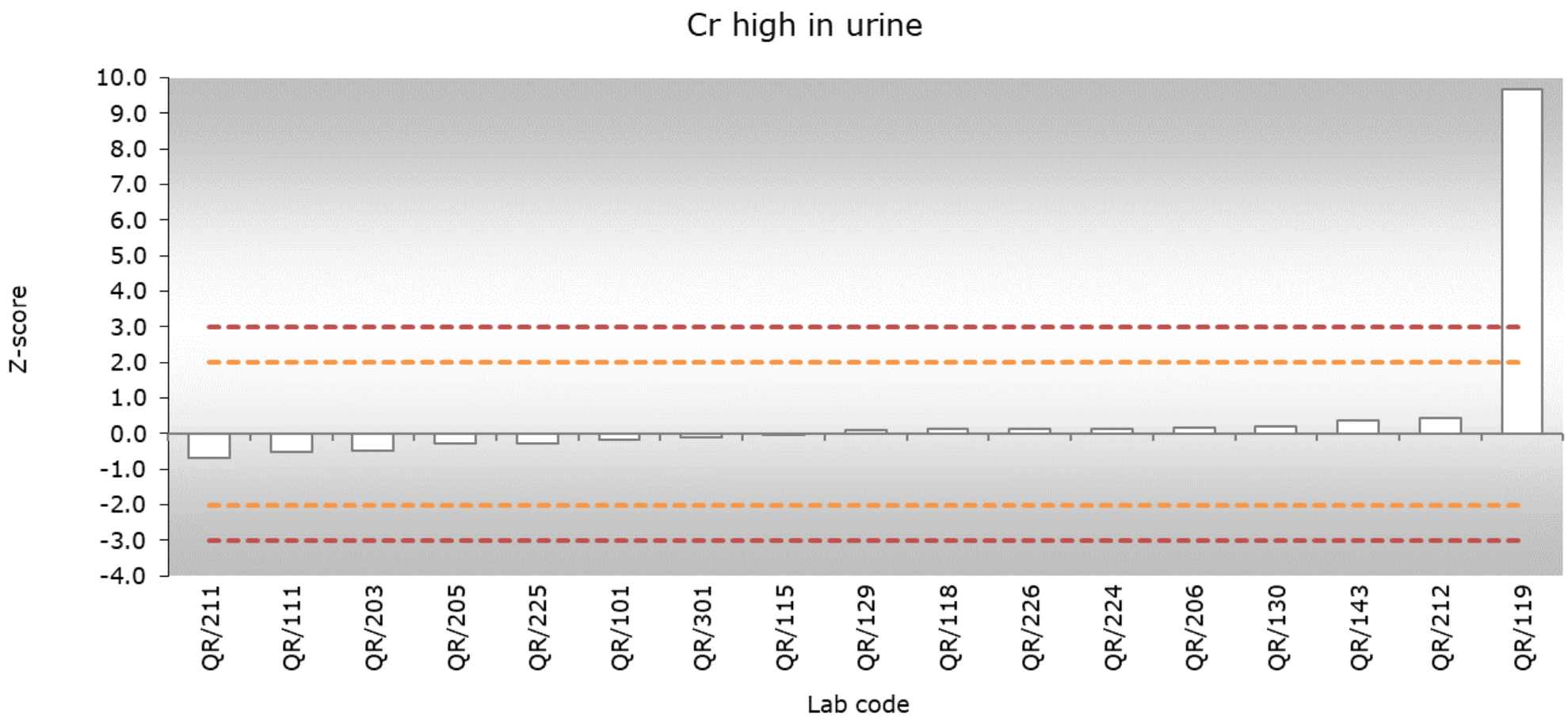
Appendix 6 Assigned values and participant's performance

HBM4EU 04/2019	Cr (urine)			
control material	Cr_{low}		Cr_{high}	
assigned value	3.066 ng/mL		10.614 ng/mL	
uncertainty of assigned value	0.071 ng/mL		0.290 ng/mL	
study RSD_R	7.6 %		9.0 %	
relative target standard deviation	25%		25%	
laboratory code	value	Z-score	value	Z-score
QR/101	2.921	**-0.19**	10.190	**-0.16**
QR/111	2.765	**-0.39**	9.293	**-0.50**
QR/115	3.270	**0.27**	10.500	**-0.04**
QR/118	3.099	**0.04**	10.980	**0.14**
QR/119	11.800	**11.39**	36.300	**9.68**
QR/129	3.140	**0.10**	10.900	**0.11**
QR/130	3.230	**0.21**	11.130	**0.19**
QR/143	3.020	**-0.06**	11.600	**0.37**
QR/203	2.960	**-0.14**	9.360	**-0.47**
QR/205	2.853	**-0.28**	9.852	**-0.29**
QR/206	3.330	**0.34**	11.040	**0.16**
QR/211	2.500	**-0.74**	8.800	**-0.68**
QR/212	3.800	**0.96**	11.800	**0.45**
QR/224	3.180	**0.15**	11.010	**0.15**
QR/225	2.883	**-0.24**	9.896	**-0.27**
QR/226	3.020	**-0.06**	11.000	**0.15**
QR/301	3.001	**-0.09**	10.363	**-0.09**

Appendix 7 Graphical representation of the Z-scores



Appendix 7 Graphical representation of the Z-scores (continued)



Appendix 8 Results and LOQs and reasons for delayed submission

HBM4EU 4/2019 Chromium in urine [ng/mL]				
Lab.code	**low**	**high**	**LOQ**	**delayed reporting**
QR/101	**2.921**	**10.190**	1.000	
QR/111	**2.765**	**9.293**	0.255	
QR/115	**3.270**	**10.500**	0.600	
QR/118	**3.099**	**10.980**	0.152	
QR/119	**11.800**	**36.300**	0.200	
QR/129	**3.140**	**10.900**	0.090	
QR/130	**3.230**	**11.130**	0.150	
QR/143	**3.020**	**11.600**	0.180	
QR/203	**2.960**	**9.360**	0.290	
QR/205	**2.853**	**9.852**	0.010	
QR/206	**3.330**	**11.040**	0.200	
QR/211	**2.500**	**8.800**	0.100	
QR/212	**3.800**	**11.800**	0.100	
QR/224	**3.180**	**11.010**	0.050	
QR/225	**2.883**	**9.896**	0.050	
QR/226	**3.020**	**11.000**	1.000	
QR/301	**3.001**	**10.363**	-	