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**Wadsworth Center**

New York State Department of Health

**TRACE ELEMENTS IN SERUM**

**Interlaboratory Study #1, 2005**

**August 24, 2005**

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**TRACE ELEMENTS**  
**Interlaboratory Study #1, 2005**

Dear Laboratory Director:

Results from the 2005 interlaboratory study of **trace elements in serum** have been tabulated and are summarized in the enclosed report. This is the third interlaboratory study for trace elements in serum and, as such, it can be considered a pilot proficiency test (PT) event. Laboratories operating under a New York State clinical laboratory permit that have applied for the permit category "*Trace Elements*", are now required to participate satisfactorily in this PT program. As of 2006, permit laboratories will be notified of their performance under separate cover, and will be advised of any actions that should be taken to improve performance should it be deemed necessary.

Target values for **Aluminum, Copper, Selenium and Zinc** were established as the consensus, all-method mean among a group of reference laboratories selected from the participant pool. Acceptable ranges are based on fixed criteria as indicated in the element-specific narrative and are similar to those used in other external quality assessment schemes for trace elements. Obviously, a laboratory with an apparent significant analytical bias relative to the target value should investigate the source of the error.

In this report, we provide a brief narrative on the nature of the test sample including the level of spike. The source of the test materials is human serum obtained from a commercial source. Some serum pools were spiked with additional trace elements (beyond Al, Se, Cu and Zn) as indicated in the appendix to this report. This information is provided solely for informational purposes. No inferences can be made regarding the mean value or the SD (where reported). However, many clinical laboratories are now using ICP-MS to determine numerous trace elements in blood/serum and urine. Where such data are available, we prefer to present them in an appendix to this report, since it provides a more comprehensive characterization of the materials used for proficiency testing purposes.

As with any new program, we expect to fine tune various aspects and fix any apparent problems as the program evolves. Our hope is that you will find this program both helpful and educational. Any issues or problems should be brought to my attention, either by telephone at 518-474-5475 or by e-mail at [patrick.parsons@wadsworth.org](mailto:patrick.parsons@wadsworth.org).

Thank you for your participation.

Yours sincerely,

Patrick J. Parsons, Ph.D.  
Section Head, Trace Elements PT program

## Serum Aluminum

The test materials for aluminum were prepared using human serum obtained from Tennessee Blood Services, Inc. The units were tested by FDA approved methods and found to be negative for HIV1/2 and HIV-1 RNA, and non-reactive to HBsAg, HCV3 and STS. Sera from several donors were pooled to make the PT base serum SE05-04. The rest of the serum units were dispensed into four acid-washed 1-L polypropylene containers to make up the remaining serum pools SE05-01, SE05-02, SE05-03 and SE05-05. These pools were spiked with a suite of additional trace elements including Al<sup>3+</sup> as illustrated below.

Sample	Al Spike (approx.)
SE05-01	60 µg/L as Al <sup>3+</sup>
SE05-02	22 µg/L as Al <sup>3+</sup>
SE05-03	100 µg/L as Al <sup>3+</sup>
SE05-04	No spike (<3.0 µg/L endogenous Al)
SE05-05	45 µg/L as Al <sup>3+</sup>

**Target values** were established as the mean of 11 referee laboratories using either ETAAS, ICP-MS or DRC/CC-ICP-MS instrumentation. Values ranged from 6.0 µg/L (0.2 µmol/L) to 88.9 µg/L (3.3 µmol/L). Among the referee pool, imprecision (SD) varied from ± 2.0 µg/L (0.07 µmol/L) to ± 9.4 µg/L (0.35 µmol/L), increasing with Al concentration.

**Acceptable ranges** for serum aluminum are based on fixed criteria of ± 20%, or ± 5 µg/L below 25 µg/L. These fixed criteria are based on consensus recommendations from several EQAS organizers (1).

**Discussion.** Results for serum Al show relatively poor interlaboratory agreement among participant laboratories. Even though 73.1% of all reported test results were satisfactory, 10 out of 32 laboratories (31%) reported 2 or more of the 5 results outside the acceptable range. One reason for this poor agreement is that serum Al concentrations in three of the five pools are below 50 µg/L. Measurement of Al at such low levels is technically difficult and complicated by ubiquitous contamination from Al in the environment. Clinically, it is more important to be able to measure serum Al accurately and reliably at levels above 100 µg/L typically found in subjects with insufficient renal function. Future serum Al panels will be designed to assess performance across the entire clinically relevant range.

(1) Taylor, A., Angerer, J., Claeys, F., Kristiansen, J., Mazarrasa, O., Menditto, A., Patriarca, M., Pineau, A., Schoeters, I., Sykes, C., Valkonen, S. and Weykamp, C. Comparison of procedures for evaluating laboratory performance in external quality assessment schemes for lead in blood and aluminum in serum demonstrates the need for common quality specifications. *Clin. Chem.* 2002 48 2000-2007

**New York State Department of Health  
Serum Aluminum Test Results, 2005 Event #1  
PERFORMANCE OF PARTICIPATING LABORATORIES**

Lab Code	Method	Results ( $\mu\text{g/L}$ serum)					Info Only
		SE05-01	SE05-02	SE05-03	SE05-04	SE05-05	
Target Values:		57.0	24.1	88.9	6.0	41.9	
110	ETAAS	63	26	101	3	44	
114	ETAAS	52	22	74	4	36	
126	ETAAS	64	23	102	<6	45	
131	ETAAS	74.0 $\uparrow$	31.4 $\uparrow$	119.2 $\uparrow$	<3	61.6 $\uparrow$	
147	ETAAS	55	23	89	5.7	40	
156	ICP-MS	51.9	20.5	86.2	8.5	39.8	
159	ETAAS	52	21	84	11	38	
160	ETAAS	67	28	106	10	51 $\uparrow$	
164	ICP-MS	56	28	88	15 $\uparrow$	43	
179	ETAAS	50	19 $\downarrow$	78	<5	37	
197	ICP-MS	66	29	95	14 $\uparrow$	49	
200	DRC/CC-ICP-MS	59	23	90	6	43	
206	ICP-MS	52	28	98	9	40	
208	ICP-MS	48	20	62 $\downarrow$	7	34	
287	ETAAS	53	20	72	14 $\uparrow$	33 $\downarrow$	
293	ETAAS	65.3	28.9	79.1	7.6	45.1	
301	ETAAS	57	16 $\downarrow$	106	<2	39	
305	ICP-MS	62.6	34.6 $\uparrow$	95.6	5.6	59.6 $\uparrow$	
314	ICP-MS	60	30 $\uparrow$	95	10	48	
324	DRC/CC-ICP-MS	123.68 $\uparrow$	36.48 $\uparrow$	83.88	9.10	29.08 $\downarrow$	Info
325	ETAAS	77.5 $\uparrow$	30.5 $\uparrow$	102.0	14.0 $\uparrow$	56.5 $\uparrow$	Info
355	ICP-MS	55	21	85	5	43	
357	ICP-AES	33.9 $\downarrow$	11.1 $\downarrow$	52.1 $\downarrow$	<5.0	26.5 $\downarrow$	
358	ICP-MS	54	28	111 $\uparrow$	6	43	
361	ETAAS	34 $\downarrow$	15 $\downarrow$	48 $\downarrow$	4	24 $\downarrow$	
362	ICP-MS	67	31 $\uparrow$	100	48 $\uparrow$	48	
363	ICP-MS	68	29	114 $\uparrow$	18 $\uparrow$	64 $\uparrow$	
364	ICP-MS	73.2 $\uparrow$	40.2 $\uparrow$	108.6 $\uparrow$	23.6 $\uparrow$	61.7 $\uparrow$	
366	ETAAS	54	23	86	5.5	45	
367	ETAAS	61.0	28.3	94.5	5.1	45.6	
377	ICP-MS	47	17 $\downarrow$	86	<3	37	
401	ICP-AES	54	16 $\downarrow$	81	<3	38	Info

Percent satisfactory results for all participants: 73.1 %

**notes:**  $\uparrow$  reported value outside upper limit  
 $\downarrow$  reported value outside lower limit

**Info only:** results included for informational purposes only.

**notes:** Results reported as less than the method detection limit are excluded from statistical calculations.

**New York State Department of Health  
Serum Aluminum Test Results, 2005 Event #1  
STATISTICAL SUMMARY**

**TARGET VALUE ASSIGNMENT AND STATISTICS**

Results ( $\mu\text{g/L}$  serum)

Lab Code	Method	Results ( $\mu\text{g/L}$ serum)				
		SE05-01	SE05-02	SE05-03	SE05-04	SE05-05
110	ETAAS	63	26	101	3	44
114	ETAAS	52	22	74	4	36
126	ETAAS	64	23	102	<6	45
147	ETAAS	55	23	89	5.7	40
156	ICP-MS	51.9	20.5	86.2	8.5	39.8
179	ETAAS	50	19	78	<5	37
200	DRC/CC-ICP-MS	59	23	90	6	43
206	ICP-MS	52	28	98	9	40
293	ETAAS	65.3	28.9	79.1	7.6	45.1
366	ETAAS	54	23	86	5.5	45
367	ETAAS	61.0	28.3	94.5	5.1	45.6
Number of Sample Measurements:		11	11	11	9	11
<b>Target value:</b>		<b>57.0</b>	<b>24.1</b>	<b>88.9</b>	<b>6.0</b>	<b>41.9</b>
Standard Deviation:		5.6	3.3	9.4	2.0	3.5
RSD (%):		9.8	13.6	10.6	33.1	8.2
Acceptable Range:						
Upper Limit:		68.4	29.1	106.7	11.0	50.3
Lower Limit:		45.6	19.1	71.1	1.0	33.5

**notes:** Results reported as less than the method detection limit are excluded from statistical calculations.

**New York State Department of Health  
Serum Aluminum Test Results, 2005 Event #1**

**STATISTICAL SUMMARY BY METHOD**

	Results ( $\mu\text{g/L}$ serum)				
	SE05-01	SE05-02	SE05-03	SE05-04	SE05-05
<b>DRC/CC-ICP-MS</b>					
Number of Sample Measurements:	1	2	2	2	2
Mean:	59.0	29.7	86.9	7.6	36.0
Standard Deviation:	?	9.5	4.3	2.2	9.8
RSD (%):	—	—	—	—	—
<b>ETAAS</b>					
Number of Sample Measurements:	15	15	15	9	15
Mean:	58.6	23.7	89.4	6.2	42.7
Standard Deviation:	10.7	5.1	17.8	2.8	9.3
RSD (%):	18.2	21.4	19.9	44.6	21.7
<b>ICP-AES</b>					
Number of Sample Measurements:	2	2	2	0	2
Mean:	44.0	13.6	66.6		32.3
Standard Deviation:	14.2	3.5	20.4		8.1
RSD (%):	—	—	—	—	—
<b>ICP-MS</b>					
Number of Sample Measurements:	13	13	13	7	13
Mean:	58.5	27.4	94.2	7.3	46.9
Standard Deviation:	8.3	6.4	13.6	1.9	9.5
RSD (%):	14.1	23.4	14.5	26.0	20.3
<b>All Laboratories</b>					
Number of Sample Measurements:	31	32	32	18	32
Mean:	57.6	24.9	89.8	6.8	43.4
Standard Deviation:	10.0	6.6	16.5	2.3	9.8
RSD (%):	17.4	26.6	18.4	34.6	22.6

**notes:** ? Insufficient data for SD calculation.

**New York State Department of Health**  
**Serum Aluminum Test Results, 2005 Event #1**  
**STATISTICAL SUMMARY BY CLASS**

	Results ( $\mu\text{g/L}$ serum)				
	SE05-01	SE05-02	SE05-03	SE05-04	SE05-05
<b>Evaluated</b>					
Number of Sample Measurements:	18	18	18	8	18
Mean:	57.1	25.0	90.4	7.3	44.6
Standard Deviation:	11.6	7.7	20.7	2.6	11.9
RSD (%):	20.3	30.7	22.9	36.2	26.7
<b>Info</b>					
Number of Sample Measurements:	2	3	3	1	3
Mean:	65.8	27.7	89.0	9.1	41.2
Standard Deviation:	16.6	10.5	11.4	?	14.0
RSD (%):	—	—	—	—	—
<b>Reference</b>					
Number of Sample Measurements:	11	11	11	9	11
Mean:	57.0	24.1	88.9	6.0	41.9
Standard Deviation:	5.6	3.3	9.4	2.0	3.5
RSD (%):	9.8	13.6	10.6	33.1	8.2
<b>All Laboratories</b>					
Number of Sample Measurements:	31	32	32	18	32
Mean:	57.6	24.9	89.8	6.8	43.4
Standard Deviation:	10.0	6.6	16.5	2.3	9.8
RSD (%):	17.4	26.6	18.4	34.6	22.6

**notes:** ? Insufficient data for SD calculation.

## Serum Copper

The test materials for copper were prepared using human serum obtained from Tennessee Blood Services, Inc. The units were tested by FDA approved methods and found to be negative for HIV1/2 and HIV-1 RNA, and non-reactive to HbsAg, HCV3 and STS. Sera from several donors were pooled to make the PT base serum SE05-04. The rest of the serum units were dispensed into four acid-washed 1-L polypropylene containers to make up the remaining serum pools SE05-01, SE05-02, SE05-03 and SE05-05. These pools were spiked with a suite of additional trace elements including Cu<sup>2+</sup> as illustrated below.

Sample	Cu Spike (approx.)
SE05-01	1000 µg/L as Cu <sup>2+</sup> (1000-1500 µg/L endogenous Cu)
SE05-02	100 µg/L as Cu <sup>2+</sup> (1000-1500 µg/L endogenous Cu)
SE05-03	1500 µg/L as Cu <sup>2+</sup> (1000-1500 µg/L endogenous Cu)
SE05-04	No spike (1000-1500 µg/L endogenous Cu)
SE05-05	300 µg/L as Cu <sup>2+</sup> (1000-1500 µg/L endogenous Cu)

**Target values** were established as the mean of 10 referee laboratories using either ETAAS, ICP-MS, ICP-AES or Flame AAS instrumentation. Values ranged from 1141.6 µg/L (18.0 µmol/L) to 2526.0 µg/L (39.8 µmol/L). Among the referee pool, imprecision (SD) varied between ± 32.1 µg/L (0.5 µmol/L) and ± 70.1 µg/L (1.1 µmol/L).

**Acceptable ranges** for serum copper are based on fixed criteria of ± 10%, or ± 10 µg/L below 100 µg/L. These criteria are similar to those proposed by the European Thematic network of EQAS organizers (1) for trace elements in serum.

**Discussion.** Results from this study show relatively poor interlaboratory agreement compared to that for other trace elements in serum. Even though 72.0% of all reported test results were satisfactory, 9 out of 25 laboratories (36%) reported 2 or more of the 5 results outside the acceptable range.

(1) Menditto, A., Patriarca, M. and Taylor, A. (personal communication, 2002).

**New York State Department of Health  
Serum Copper Test Results, 2005 Event #1  
PERFORMANCE OF PARTICIPATING LABORATORIES**

Lab Code	Method	Results ( $\mu\text{g/L}$ serum)					Info Only
		SE05-01	SE05-02	SE05-03	SE05-04	SE05-05	
Target Values:		2033.6	1385.3	2526.0	1141.6	1485.9	
107	ICP-AES	2069	1363	2546	1158	1514	
110	ICP-MS	2087	1386	2625	1184	1633	
114	ICP-MS	1890	1240 ↓	2340	1140	1360	
147	ICP-MS	1989	1366	2459	1144	1442	
156	Flame AAS	2300 ↑	1540 ↑	2850 ↑	1290 ↑	1710 ↑	
159	ICP-AES	2073	1355	2559	1152	1520	
160	ETAAS	1900	1180 ↓	2400	1050	1300 ↓	
164	ICP-MS	2027	1382	2459	1128	1454	
179	ICP-AES	2010	1390	2600	1180	1450	
197	ICP-MS	2000	1310	2500	1120	1470	
200	Flame AAS	2118	1414	2593	1160	1534	
206	ICP-MS	2260 ↑	1670 ↑	2510	1270 ↑	1790 ↑	
208	ICP-MS	1747 ↓	1170 ↓	1966 ↓	977 ↓	1339	
290	ETAAS	1990	1530 ↑	2530	1150	1440	
293	Flame AAS	1981	1346	2407	1080	1461	
305	ICP-MS	1858	1211 ↓	2403	1030	1346	
324	DRC/CC-ICP-MS	1790 ↓	1200 ↓	2300	1020 ↓	1380	Info
325	Flame AAS	1880	1250	2270 ↓	1010 ↓	1320 ↓	Info
351	Flame AAS	2310 ↑	1600 ↑	3060 ↑	1350 ↑	1720 ↑	
360	Flame AAS	1800 ↓	1200 ↓	2300	1150	1350	
362	ICP-MS	2300 ↑	1570 ↑	2680	1270 ↑	1600	
364	ICP-MS	2163	1497	2744	1295 ↑	1517	
366	ETAAS	1900	1314	2418	1120	1446	Info
377	ICP-MS	1958	1282	2409	1079	1450	
401	ICP-AES	2065	1366	2541	1112	1461	

Percent satisfactory results for all participants: 72.0 %

**notes:** ↑ reported value outside upper limit  
↓ reported value outside lower limit

**Info only:** results included for informational purposes only.

**notes:** Results reported as less than the method detection limit are excluded from statistical calculations.

**New York State Department of Health  
Serum Copper Test Results, 2005 Event #1  
STATISTICAL SUMMARY**

**TARGET VALUE ASSIGNMENT AND STATISTICS**

Results ( $\mu\text{g/L}$  serum)

Lab Code	Method	Results ( $\mu\text{g/L}$ serum)				
		SE05-01	SE05-02	SE05-03	SE05-04	SE05-05
107	ICP-AES	2069	1363	2546	1158	1514
110	ICP-MS	2087	1386	2625	1184	1633
147	ICP-MS	1989	1366	2459	1144	1442
164	ICP-MS	2027	1382	2459	1128	1454
179	ICP-AES	2010	1390	2600	1180	1450
197	ICP-MS	2000	1310	2500	1120	1470
200	Flame AAS	2118	1414	2593	1160	1534
290	ETAAS	1990	1530	2530	1150	1440
293	Flame AAS	1981	1346	2407	1080	1461
401	ICP-AES	2065	1366	2541	1112	1461
Number of Sample Measurements:		10	10	10	10	10
<b>Target value:</b>		<b>2033.6</b>	<b>1385.3</b>	<b>2526.0</b>	<b>1141.6</b>	<b>1485.9</b>
Standard Deviation:		47.8	58.0	70.1	32.1	60.2
RSD (%):		2.4	4.2	2.8	2.8	4.0
Acceptable Range:						
Upper Limit:		2237.0	1523.8	2778.6	1255.8	1634.5
Lower Limit:		1830.2	1246.8	2273.4	1027.4	1337.3

**notes:** Results reported as less than the method detection limit are excluded from statistical calculations.

**New York State Department of Health  
Serum Copper Test Results, 2005 Event #1  
STATISTICAL SUMMARY BY METHOD**

	Results ( $\mu\text{g/L}$ serum)				
	SE05-01	SE05-02	SE05-03	SE05-04	SE05-05
<b>DRC/CC-ICP-MS</b>					
Number of Sample Measurements:	1	1	1	1	1
Mean:	1790.0	1200.0	2300.0	1020.0	1380.0
Standard Deviation:	?	?	?	?	?
RSD (%):	—	—	—	—	—
<b>ETAAS</b>					
Number of Sample Measurements:	3	3	3	3	3
Mean:	1930.0	1341.3	2449.3	1106.7	1395.3
Standard Deviation:	52.0	176.6	70.4	51.3	82.6
RSD (%):	—	—	—	—	—
<b>Flame AAS</b>					
Number of Sample Measurements:	6	6	6	6	6
Mean:	2064.8	1391.7	2580.0	1173.3	1515.8
Standard Deviation:	214.3	158.0	318.7	127.2	172.4
RSD (%):	10.4	11.4	12.4	10.8	11.4
<b>ICP-AES</b>					
Number of Sample Measurements:	4	4	4	4	4
Mean:	2054.3	1368.5	2561.5	1150.5	1486.3
Standard Deviation:	29.7	15.1	26.8	28.3	35.9
RSD (%):	1.4	1.1	1.0	2.5	2.4
<b>ICP-MS</b>					
Number of Sample Measurements:	11	11	11	11	11
Mean:	2025.4	1371.3	2463.2	1148.8	1491.0
Standard Deviation:	168.4	154.9	206.0	100.9	137.6
RSD (%):	8.3	11.3	8.4	8.8	9.2
<b>All Laboratories</b>					
Number of Sample Measurements:	25	25	25	25	25
Mean:	2018.6	1365.3	2498.8	1144.8	1480.3
Standard Deviation:	160.1	138.7	210.2	94.8	128.5
RSD (%):	7.9	10.2	8.4	8.3	8.7

**notes:** ? Insufficient data for SD calculation.

**New York State Department of Health  
Serum Copper Test Results, 2005 Event #1  
STATISTICAL SUMMARY BY CLASS**

	Results ( $\mu\text{g/L}$ serum)				
	SE05-01	SE05-02	SE05-03	SE05-04	SE05-05
<b>Evaluated</b>					
Number of Sample Measurements:	12	12	12	12	12
Mean:	2046.6	1376.3	2518.4	1171.1	1500.2
Standard Deviation:	212.7	186.5	287.0	121.9	171.0
RSD (%):	10.4	13.6	11.4	10.4	11.4
<b>Info</b>					
Number of Sample Measurements:	3	3	3	3	3
Mean:	1856.7	1254.7	2329.3	1050.0	1382.0
Standard Deviation:	58.6	57.1	78.2	60.8	63.0
RSD (%):	—	—	—	—	—
<b>Reference</b>					
Number of Sample Measurements:	10	10	10	10	10
Mean:	2033.6	1385.3	2526.0	1141.6	1485.9
Standard Deviation:	47.8	58.0	70.1	32.1	60.2
RSD (%):	2.4	4.2	2.8	2.8	4.0
<b>All Laboratories</b>					
Number of Sample Measurements:	25	25	25	25	25
Mean:	2018.6	1365.3	2498.8	1144.8	1480.3
Standard Deviation:	160.1	138.7	210.2	94.8	128.5
RSD (%):	7.9	10.2	8.4	8.3	8.7

**notes:** ? Insufficient data for SD calculation.

## Serum Selenium

The test materials for selenium were prepared using human serum obtained from Tennessee Blood Services, Inc. The units were tested by FDA approved methods and found to be negative for HIV1/2 and HIV-1 RNA, and non-reactive to HbsAg, HCV3 and STS. Sera from several donors were pooled to make the PT base serum SE05-04. The rest of the serum units were dispensed into four acid-washed 1-L polypropylene containers to make up the remaining serum pools SE05-01, SE05-02, SE05-04 and SE05-05. These pools were spiked with a suite of additional trace elements including Se<sup>4+</sup> as illustrated below.

Sample	Se Spike (approx.)
SE05-01	130 µg/L (100-130 µg/L endogenous Se)
SE05-02	60 µg/L as Se <sup>4+</sup> (100-130 µg/L endogenous Se)
SE05-03	160 µg/L as Se <sup>4+</sup> (100-130 µg/L endogenous Se)
SE05-04	No spike (100-130 µg/L endogenous Se)
SE05-05	80 µg/L as Se <sup>4+</sup> (100-130 µg/L endogenous Se)

**Target values** were established as the mean of 11 referee laboratories using either ETAAS, ICP-MS or DRC/CC-ICP-MS instrumentation. Values ranged from 112.7 µg/L (1.4 µmol/L) to 301.1 µg/L (3.8 µmol/L). Among the referee pool, imprecision (SD) varied between ± 7.3 µg/L (0.1 µmol/L) and ± 21.4 µg/L (0.3 µmol/L).

**Acceptable ranges** for serum selenium are based on fixed criteria of ± 20%, or ± 2 µg/L below 10 µg/L. These criteria are similar to those proposed by the European Thematic network of EQAS organizers (1) for trace elements in serum and the Institut National de Santé Publique du Québec for their trace elements in serum program.

**Discussion.** Results from this study show relatively good interlaboratory agreement. Based upon the criteria, 89.0% of all reported test results were satisfactory, with only 4 out of 20 laboratories (20%) reporting 2 or more of the 5 results outside the acceptable range.

1. Menditto, A., Patriarca, M. and Taylor, A. (personal communication, 2002).

**New York State Department of Health  
Serum Selenium Test Results, 2005 Event #1  
PERFORMANCE OF PARTICIPATING LABORATORIES**

Lab Code	Method	Results ( $\mu\text{g/L}$ serum)					Info Only
		SE05-01	SE05-02	SE05-03	SE05-04	SE05-05	
Target Values:		228.2	168.1	301.1	112.7	196.0	
107	DRC/CC-ICP-MS	226	164	301	112	208	
110	DRC/CC-ICP-MS	224	166	304	113	195	
114	ICP-MS	225	171	286	112	195	
147	ICP-MS	227	168	304	118	189	
156	ETAAS	236	183	304	129	222	
159	ETAAS	213	161	272	119	195	
164	ETAAS	214	149	276	99	171	
179	ICP-MS	217	159	290	109	188	
197	ICP-MS	231	179	307	123	197	
200	DRC/CC-ICP-MS	215	156	288	107	186	
206	ICP-MS	163 ↓	148	214 ↓	93	117 ↓	
208	ICP-MS	199	143	270	132	206	
293	ICP-MS	262	176	349	118	227	
305	ICP-MS	225	171	299	117	193	
324	DRC/CC-ICP-MS	295 ↑	207 ↑	387 ↑	131	510 ↑	Info
364	ICP-MS	259	202 ↑	351	146 ↑	221	
366	ETAAS	194	136	265	98	175	Info
367	ETAAS	237	191	285	127	194	
401	ETAAS	238	178	330	108	210	
403	ETAAS	254	178	355	140 ↑	237 ↑	

Percent satisfactory results for all participants: 89.0 %

**notes:** ↑ reported value outside upper limit  
↓ reported value outside lower limit

**Info only:** results included for informational purposes only.

**notes:** Results reported as less than the method detection limit are excluded from statistical calculations.

**New York State Department of Health  
Serum Selenium Test Results, 2005 Event #1  
STATISTICAL SUMMARY**

**TARGET VALUE ASSIGNMENT AND STATISTICS**

Results ( $\mu\text{g/L}$  serum)

Lab Code	Method	Results ( $\mu\text{g/L}$ serum)				
		SE05-01	SE05-02	SE05-03	SE05-04	SE05-05
107	DRC/CC-ICP-MS	226	164	301	112	208
110	DRC/CC-ICP-MS	224	166	304	113	195
114	ICP-MS	225	171	286	112	195
147	ICP-MS	227	168	304	118	189
164	ETAAS	214	149	276	99	171
179	ICP-MS	217	159	290	109	188
200	DRC/CC-ICP-MS	215	156	288	107	186
293	ICP-MS	262	176	349	118	227
305	ICP-MS	225	171	299	117	193
367	ETAAS	237	191	285	127	194
401	ETAAS	238	178	330	108	210
Number of Sample Measurements:		11	11	11	11	11
<b>Target value:</b>		<b>228.2</b>	<b>168.1</b>	<b>301.1</b>	<b>112.7</b>	<b>196.0</b>
Standard Deviation:		13.6	11.5	21.4	7.3	14.7
RSD (%):		6.0	6.8	7.1	6.5	7.5
Acceptable Range:						
Upper Limit:		273.8	201.7	361.3	135.2	235.2
Lower Limit:		182.6	134.5	240.9	90.2	156.8

**notes:** Results reported as less than the method detection limit are excluded from statistical calculations.

**New York State Department of Health  
Serum Selenium Test Results, 2005 Event #1**

**STATISTICAL SUMMARY BY METHOD**

	Results ( $\mu\text{g/L}$ serum)				
	SE05-01	SE05-02	SE05-03	SE05-04	SE05-05
<b>DRC/CC-ICP-MS</b>					
Number of Sample Measurements:	4	4	4	4	3
Mean:	240.0	173.3	320.0	115.8	196.3
Standard Deviation:	37.0	22.9	45.2	10.5	11.1
RSD (%):	15.4	13.2	14.1	9.1	—
<b>ETAAS</b>					
Number of Sample Measurements:	7	7	7	7	7
Mean:	226.6	168.0	298.1	117.1	200.6
Standard Deviation:	20.3	19.9	33.5	16.0	24.1
RSD (%):	9.0	11.9	11.2	13.7	12.0
<b>ICP-MS</b>					
Number of Sample Measurements:	9	9	9	9	9
Mean:	223.1	168.6	296.7	118.7	192.6
Standard Deviation:	29.8	17.5	41.2	14.8	31.5
RSD (%):	13.4	10.4	13.9	12.4	16.4
<b>All Laboratories</b>					
Number of Sample Measurements:	20	20	20	20	19
Mean:	227.7	169.3	301.9	117.6	196.1
Standard Deviation:	27.6	18.5	38.4	13.8	25.7
RSD (%):	12.1	10.9	12.7	11.8	13.1

**notes:** ? Insufficient data for SD calculation.

**New York State Department of Health**  
**Serum Selenium Test Results, 2005 Event #1**  
**STATISTICAL SUMMARY BY CLASS**

	Results ( $\mu\text{g/L}$ serum)				
	SE05-01	SE05-02	SE05-03	SE05-04	SE05-05
<b>Evaluated</b>					
Number of Sample Measurements:	7	7	7	7	7
Mean:	222.1	170.6	296.1	126.0	199.3
Standard Deviation:	33.6	20.9	49.4	17.3	39.3
RSD (%):	15.1	12.3	16.7	13.7	19.7
<b>Info</b>					
Number of Sample Measurements:	2	2	2	2	1
Mean:	244.5	171.5	326.0	114.5	175.0
Standard Deviation:	71.4	50.2	86.3	23.3	?
RSD (%):	—	—	—	—	—
<b>Reference</b>					
Number of Sample Measurements:	11	11	11	11	11
Mean:	228.2	168.1	301.1	112.7	196.0
Standard Deviation:	13.6	11.5	21.4	7.3	14.7
RSD (%):	6.0	6.8	7.1	6.5	7.5
<b>All Laboratories</b>					
Number of Sample Measurements:	20	20	20	20	19
Mean:	227.7	169.3	301.9	117.6	196.1
Standard Deviation:	27.6	18.5	38.4	13.8	25.7
RSD (%):	12.1	10.9	12.7	11.8	13.1

**notes:** ? Insufficient data for SD calculation.

## Serum Zinc

The test materials for zinc were prepared using human serum obtained from Tennessee Blood Services, Inc. The units were tested by FDA approved methods and found to be negative for HIV1/2 and HIV-1 RNA, and non-reactive to HbsAg, HCV3 and STS. Sera from several donors were pooled to make the PT base serum SE05-04. The rest of the serum units were dispensed into four acid-washed 1-L polypropylene containers to make up the remaining serum pools SE05-01, SE05-02, SE05-03 and SE05-05. These pools were spiked with a suite of additional trace elements including Zn<sup>2+</sup> as illustrated below.

Sample	Zn Spike (approx.)
SE05-01	1400 µg/L as Zn <sup>2+</sup> (<1000 µg/L endogenous Zn)
SE05-02	100 µg/L as Zn <sup>2+</sup> (<1000 µg/L endogenous Zn)
SE05-03	1670 µg/L as Zn <sup>2+</sup> (<1000 µg/L endogenous Zn)
SE05-04	No spike (<1000 µg/L endogenous Zn)
SE05-05	200 µg/L as Zn <sup>2+</sup> (<1000 µg/L endogenous Zn)

**Target values** were established as the mean of 11 referee laboratories using either ICP-MS, ICP-AES, Flame AAS or DRC/CC-ICP-MS instrumentation. Values ranged from 697.8 µg/L (10.7 µmol/L) to 3388.1 µg/L (51.8 µmol/L). Among the referee pool, imprecision (SD) varied between ± 39.9 µg/L (0.6 µmol/L) to ± 169.7 µg/L (2.6 µmol/L), increasing with Zn concentration.

**Acceptable ranges** for serum zinc are based on fixed criteria of ± 15%, or ± 15 µg/L below 100 µg/L. These criteria are similar to those proposed by the European Thematic network of EQAS organizers (1) for trace elements in serum.

**Discussion.** Results from this study show relatively good interlaboratory agreement. Based upon the criteria, 86.1% of all reported test results were satisfactory, with only 7 out of 33 laboratories (21%) reporting 2 or more of the 5 results outside the acceptable range.

1. Menditto, A., Patriarca, M. and Taylor, A. (personal communication, 2002).

**New York State Department of Health  
Serum Zinc Test Results, 2005 Event #1  
PERFORMANCE OF PARTICIPATING LABORATORIES**

Lab Code	Method	Results ( $\mu\text{g/L}$ serum)					Info Only
		SE05-01	SE05-02	SE05-03	SE05-04	SE05-05	
Target Values:		2375.5	852.8	3388.1	697.8	971.2	
107	ICP-AES	2435	876	3552	701	991	
110	ICP-MS	2450	880	3546	732	1094	
114	ICP-MS	2200	770	3260	680	890	
125	Flame AAS	2600	860	3540	690	1010	
131	Other	26.6 ↓	9.4 ↓	38.1 ↓	7.5 ↓	10.8 ↓	
147	ICP-MS	2255	843	3196	752	922	
156	ICP-MS	2238	762	3039	618	907	
159	ICP-AES	2327	831	3337	681	962	
160	Flame AAS	2410	770	3500	670	900	
164	ICP-MS	2346	822	3357	663	912	
179	ICP-AES	2450	880	3510	720	980	
197	ICP-MS	2280	810	3360	670	950	
200	Flame AAS	2459	896	3473	700	981	
206	ICP-MS	2410	960	2820 ↓	700	1120 ↑	
208	ICP-MS	2079	846	2794 ↓	681	1029	
287	Flame AAS	1860 ↓	690 ↓	2890	610	820 ↓	
290	ETAAS	2310	810	3350	720	850	
293	Flame AAS	2322	916	3172	654	948	
305	ICP-MS	2080	737	3145	608	844	
324	DRC/CC-ICP-MS	2410	910	3350	720	1070	
325	Flame AAS	2370	810	3440	720	920	
351	Flame AAS	2600	880	3560	740	1020	
355	ICP-MS	2353	817	3308	689	988	
357	ICP-AES	2010 ↓	676 ↓	2920	643	1060	
358	ICP-MS	2082	901	3407	880 ↑	950	
360	Flame AAS	2460	870	3460	730	1000	
361	Flame AAS	2810 ↑	890	4100 ↑	820 ↑	1080	
362	ICP-MS	235 ↓	950	3120	810 ↑	940	
363	ICP-MS	2590	1030 ↑	4100 ↑	920 ↑	1200 ↑	
364	ICP-MS	2516	936	3661	762	988	
366	Flame AAS	2450	980	3460	650	1020	
377	ICP-MS	2329	852	3174	715	989	
401	ICP-AES	2549	883	3595	719	1013	

Percent satisfactory results for all participants: 86.1 %

**notes:** ↑ reported value outside upper limit  
↓ reported value outside lower limit

**Info only:** results included for informational purposes only.

**notes:** Results reported as less than the method detection limit are excluded from statistical calculations.

**New York State Department of Health  
Serum Zinc Test Results, 2005 Event #1  
STATISTICAL SUMMARY**

**TARGET VALUE ASSIGNMENT AND STATISTICS**

Results ( $\mu\text{g/L}$  serum)

Lab Code	Method	Results ( $\mu\text{g/L}$ serum)				
		SE05-01	SE05-02	SE05-03	SE05-04	SE05-05
107	ICP-AES	2435	876	3552	701	991
110	ICP-MS	2450	880	3546	732	1094
114	ICP-MS	2200	770	3260	680	890
125	Flame AAS	2600	860	3540	690	1010
147	ICP-MS	2255	843	3196	752	922
200	Flame AAS	2459	896	3473	700	981
293	Flame AAS	2322	916	3172	654	948
305	ICP-MS	2080	737	3145	608	844
324	DRC/CC-ICP-MS	2410	910	3350	720	1070
325	Flame AAS	2370	810	3440	720	920
401	ICP-AES	2549	883	3595	719	1013
Number of Sample Measurements:		11	11	11	11	11
<b>Target value:</b>		<b>2375.5</b>	<b>852.8</b>	<b>3388.1</b>	<b>697.8</b>	<b>971.2</b>
Standard Deviation:		152.7	57.9	169.7	39.9	75.5
RSD (%):		6.4	6.8	5.0	5.7	7.8
Acceptable Range:						
Upper Limit:		2731.8	980.7	3896.3	802.5	1116.9
Lower Limit:		2019.2	724.9	2879.9	593.1	825.5

**notes:** Results reported as less than the method detection limit are excluded from statistical calculations.

**New York State Department of Health  
Serum Zinc Test Results, 2005 Event #1  
STATISTICAL SUMMARY BY METHOD**

	Results ( $\mu\text{g/L}$ serum)				
	SE05-01	SE05-02	SE05-03	SE05-04	SE05-05
<b>DRC/CC-ICP-MS</b>					
Number of Sample Measurements:	1	1	1	1	1
Mean:	2410.0	910.0	3350.0	720.0	1070.0
Standard Deviation:	?	?	?	?	?
RSD (%):	—	—	—	—	—
<b>ETAAS</b>					
Number of Sample Measurements:	1	1	1	1	1
Mean:	2310.0	810.0	3350.0	720.0	850.0
Standard Deviation:	?	?	?	?	?
RSD (%):	—	—	—	—	—
<b>Flame AAS</b>					
Number of Sample Measurements:	10	10	10	10	10
Mean:	2434.1	856.2	3459.5	698.4	969.9
Standard Deviation:	246.0	81.4	304.8	58.7	74.6
RSD (%):	10.1	9.5	8.8	8.4	7.7
<b>ICP-AES</b>					
Number of Sample Measurements:	5	5	5	5	5
Mean:	2354.2	829.2	3382.8	692.8	1001.2
Standard Deviation:	207.9	88.2	276.6	32.1	37.7
RSD (%):	8.8	10.6	8.2	4.6	3.8
<b>ICP-MS</b>					
Number of Sample Measurements:	14	15	15	15	15
Mean:	2300.6	861.1	3285.8	725.3	981.5
Standard Deviation:	159.8	81.9	325.7	88.4	95.2
RSD (%):	6.9	9.5	9.9	12.2	9.7
<b>Other</b>					
Number of Sample Measurements:	0	0	0	0	0
Mean:					
Standard Deviation:					
RSD (%):	—	—	—	—	—
<b>All Laboratories</b>					
Number of Sample Measurements:	31	32	32	32	32
Mean:	2356.1	854.5	3359.3	711.5	979.6
Standard Deviation:	196.5	79.0	301.2	69.8	82.5
RSD (%):	8.3	9.3	9.0	9.8	8.4

**notes:** ? Insufficient data for SD calculation.

**New York State Department of Health  
Serum Zinc Test Results, 2005 Event #1  
STATISTICAL SUMMARY BY CLASS**

	Results ( $\mu\text{g/L}$ serum)				
	SE05-01	SE05-02	SE05-03	SE05-04	SE05-05
<b>Evaluated</b>					
Number of Sample Measurements:	20	21	21	21	21
Mean:	2345.5	855.4	3344.1	718.7	984.0
Standard Deviation:	219.9	89.5	354.3	81.2	87.4
RSD (%):	9.4	10.5	10.6	11.3	8.9
<b>Reference</b>					
Number of Sample Measurements:	11	11	11	11	11
Mean:	2375.5	852.8	3388.1	697.8	971.2
Standard Deviation:	152.7	57.9	169.7	39.9	75.5
RSD (%):	6.4	6.8	5.0	5.7	7.8
<b>All Laboratories</b>					
Number of Sample Measurements:	31	32	32	32	32
Mean:	2356.1	854.5	3359.3	711.5	979.6
Standard Deviation:	196.5	79.0	301.2	69.8	82.5
RSD (%):	8.3	9.3	9.0	9.8	8.4

**notes:** ? Insufficient data for SD calculation.

## Additional Trace Elements Reported in Serum

For this interlaboratory study, we requested that participant laboratories report their analytical results for any additional trace elements (other than Al, Cu, Se and Zn) that are routinely reported so that a more complete characterization can be recorded for these materials. Results for additional trace elements are reported here, but no target values are implied nor are any acceptable ranges provided. These data are provided solely for educational and informational purposes.

In addition to Al, Cu, Se and Sn, serum pools were supplemented with additional trace elements as indicated in the table below.

### Additional Elements

As, Ba, Be, Cd, Co, Cr, Mn, Pb, Sb, Sn, Te, Tl and U

**New York State Department of Health  
Interlaboratory Study, 2005 Event #1**

**SE05-01**

**Additional Elements**

	Lab Code	110	197	206	n	Mean	S.D.	% RSD
	Technique	ICP-MS	ICP-MS (As, Cr, Mn, = DRC/CC- ICP-MS)	ICP-MS (Cr = DRC/CC- ICP-MS)				
As (µg/L)			17					
Ba (µg/L)		8.0						
Be (µg/L)		6.2						
Cd (µg/L)		6.8	5.6		2	6.2		
Co (µg/L)		2.3	2.7	1.7	3	2.2	0.5	22.5
Cr (µg/L)			6.4	6.0	2	6.2		
Hg (µg/L)			< 5					
Mn (µg/L)			7.8	6.5	2	7.2		
Mo (µg/L)		8.0						
Pb (µg/L)		33.6	31.5		2	32.6		
Sb (µg/L)		7.1						
Sn (µg/L)		8.2						
Te (µg/L)		2.8						
Tl (µg/L)		3.2	3.2		2			
U (µg/L)		0.87						

**New York State Department of Health  
Interlaboratory Study, 2005 Event #1**

**SE05-02**

**Additional Elements**

	Lab Code	110	197	206	n	Mean	S.D.	% RSD
	Technique	ICP-MS	ICP-MS (As, Cr, Mn, = DRC/CC- ICP-MS)	ICP-MS (Cr = DRC/CC- ICP-MS)				
As (µg/L)			12					
Ba (µg/L)		3.7						
Be (µg/L)		2.9						
Cd (µg/L)		2.4	2.0		2	2.2		
Co (µg/L)		1.7	2.1	1.5	3	1.8	0.3	17.3
Cr (µg/L)			5.6	6.5	2	6.1		
Hg (µg/L)			< 5					
Mn (µg/L)			4.0	5.3	2	4.7		
Mo (µg/L)		32.1						
Pb (µg/L)		36.5	34.4		2	35.5		
Sb (µg/L)		2.6						
Sn (µg/L)		7.1						
Te (µg/L)		3.0						
Tl (µg/L)		5.9	5.6		2	5.8		
U (µg/L)		0.32						

**New York State Department of Health  
Interlaboratory Study, 2005 Event #1**

**SE05-03**

**Additional Elements**

	Lab Code	110	197	206	n	Mean	S.D.	% RSD
	Technique	ICP-MS	ICP-MS (As, Cr, Mn, = DRC/CC- ICP-MS)	ICP-MS (Cr = DRC/CC- ICP-MS)				
As (µg/L)			25					
Ba (µg/L)		12						
Be (µg/L)		9.9						
Cd (µg/L)		10.7	9.1		2	9.9		
Co (µg/L)		4.0	4.6	2.6	3	3.7	1.0	27.5
Cr (µg/L)			10.1	9.6	2	9.9		
Hg (µg/L)			< 5					
Mn (µg/L)			11.5	11.0	2	11.3		
Mo (µg/L)		13.1						
Pb (µg/L)		55.3	50.3		2	52.8		
Sb (µg/L)		11.6						
Sn (µg/L)		12.1						
Te (µg/L)		4.9						
Tl (µg/L)		5.4	5.1		2	5.3		
U (µg/L)		1.41						

**New York State Department of Health  
Interlaboratory Study, 2005 Event #1**

**SE05-04**

**Additional Elements**

	Lab Code	110	197	206	n	Mean	S.D.	% RSD
	Technique	ICP-MS	ICP-MS (As, Cr, Mn, = DRC/CC- ICP-MS)	ICP-MS (Cr = DRC/CC- ICP-MS)				
As (µg/L)			< 10					
Ba (µg/L)		0.95						
Be (µg/L)		0.07						
Cd (µg/L)		< 0.3	< 0.5					
Co (µg/L)		0.6	< 1.0	0.6				
Cr (µg/L)			< 0.5	0.2				
Hg (µg/L)			< 5					
Mn (µg/L)			1.1	1.6	2	1.4		
Mo (µg/L)		2.1						
Pb (µg/L)		< 0.2	< 0.4					
Sb (µg/L)		0.04						
Sn (µg/L)		0.95						
Te (µg/L)		0.35						
Tl (µg/L)		< 0.07	< 1.0					
U (µg/L)		< 0.05						

**New York State Department of Health  
Interlaboratory Study, 2005 Event #1**

**SE05-05**

**Additional Elements**

	Lab Code	110	197	206	n	Mean	S.D.	% RSD
	Technique	ICP-MS	ICP-MS (As, Cr, Mn, = DRC/CC- ICP-MS)	ICP-MS (Cr = DRC/CC- ICP-MS)				
As (µg/L)			23					
Ba (µg/L)		7.1						
Be (µg/L)		6.0						
Cd (µg/L)		5.2	4.4		2	4.8		
Co (µg/L)		3.2	3.6	2.3	3	3.0	0.7	22.0
Cr (µg/L)			11.6	10.6	2	11.1		
Hg (µg/L)			< 5					
Mn (µg/L)			5.8	8.4	2	7.1		
Mo (µg/L)		6.4						
Pb (µg/L)		75.4	66.0		2	70.7		
Sb (µg/L)		5.4						
Sn (µg/L)		13.3						
Te (µg/L)		4.0						
Tl (µg/L)		12.1	12.4		2	12.3		
U (µg/L)		0.38						

**New York State Department of Health**  
**TRACE ELEMENTS**  
**METHOD NOTES**

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**FAAS:**

Flame atomic absorption spectrometry

**ETAAS:**

Electrothermal (i.e., graphite furnace) atomic absorption spectrometry

**ICP-AES:**

Inductively-coupled plasma atomic emission spectrometry

**ICP-MS:**

Inductively-coupled plasma mass spectrometry (standard mode)

**DRC/CC-ICP-MS:**

Inductively-coupled plasma mass spectrometry equipped with dynamic reaction cell (DRC) or collision cell (CC) technology

**HG-AAS:**

Hydride generation - atomic absorption spectrometry

**HG-AFS:**

Hydride generation - atomic fluorescence spectrometry

**CV-AAS:**

Cold-vapor atomic absorption spectrometry

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