GUIDELINES FOR THE ANALYSIS FOR WP4

Important considerations:

- Distribution of the analysis tasks among the WP4 members:

Institute	Procedure
Bfs	Y-90 Preparation and administration
SCK-CEN	F-18 Preparation
IRSN	F-18 Administration
UPC	Tc-99m Preparation
CHUV	Tc-99m Administration

- The data to be used for the analysis are all data available from WP4 measurement partners. It can be found in the file named: "database for results", available in the forum. Last update: wp4 database 25ag2010without pivot table.xls.
- **For diagnostics procedures, it will be only considered a worker with at least 4 measurements for the same procedure.**
  Results indicated at the end of the file where contamination happened should not be considered for routine analysis and can be used in a different analysis. If you do not consider a worker for the analysis, please give the reasons for this choice.
- The results are presented as **results for dominant or non dominant hand** (instead of left and right).
- Doses should be always normalized by the activity: the activity of preparation for the labeling process (legend of database) and by the activity administered to the patient for the injection process. The units to be used are μSv/GBq. To facilitate the text reading, each time that "dose" is mentioned in these guidelines, unless specified otherwise, we "normalized dose by the activity".
- All results should be presented in excel format.
- **For injection procedures the analysis should be performed for workers using shielding and workers not using shielding, independently.**

The analysis should include at least the following tables and figures (suggestions are welcome):

1. A table describing the number of measurements. Indicate the workers that have not been considered for the analysis. See example Table 1.

2. A table of results showing for each worker: mean, standard deviation, median, maximum and minimum doses for each measurement position and mean manipulated activity in GBq. See example in Table 5. Throughout the text, we will often refer to this table, please don't take the values, only the format and the manner to compute the data.

Procedure (P/A)	A	
Hand (L/R)	(Tous)	
Ref. Lab	Ref. Hosp.	Ref. worker	N° measurements
A	HA1	T1HA1	5
		T3HA1	5
	HA2	T4HA2	4
		T5HA2	2
	HA3	T4HA3	1
	HA4	T2HA4	1
		T3HA4	5
B	HB1	T6HB1	1
		T9HB1	1
	HB2	T2HB2	1
D	HD1	T2HD1	1
		T3HD1	1
		T5HD1	1
		T6HD1	1
E	HE1	T2HE1	5
		T4HE1	5
	HE2	T1HE2	5
		T2HE2	5
F	HF1	T5HF1	3
	HF2	T2HF2	1
	HF3	T1HF3	5
	HF4	T1HF4	5
		T2HF4	5
	HF6	T1HF6	2
		T6HF6	3
	HF7	T2HF7	3
		T3HF7	1
G	HG3	T2HG3	5
		T4HG3	5
	HG4	T3HG4	5
		T4HG4	5
Total général			98

Table 1: Example: Status of measurements of Tc99m administration, database 20march2010.

3. Plots to display the data:

   a. Box plot of doses per technician vs. TLDs positions in the hand, for dominant and non dominant hand. See example in Figure 1. (Ideally, you will have 24 box plots, one per technician; different number for therapy)

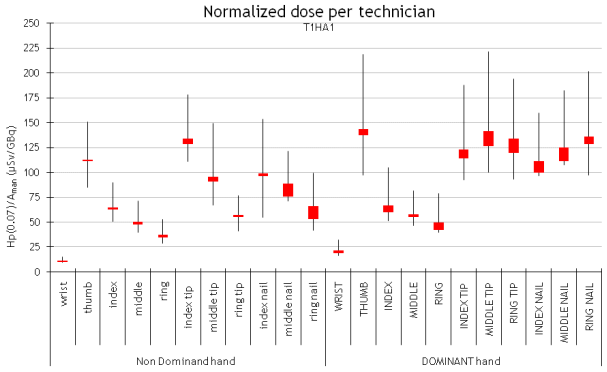
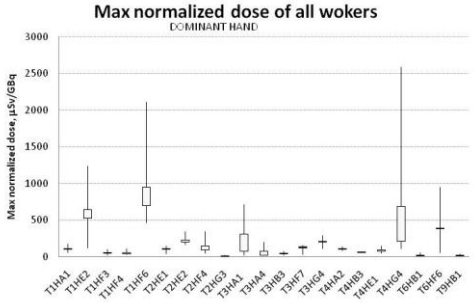


Figure 1: Box plot doses per technician.

   b. To see the differences between workers, do three box plots.
      - First: one box plot for dominant hand and one for non dominant hand. For each technician consider the mean of the maximum dose found for the different workers. See example in Figure 2.

   N.B.: To do the box plot use the five measurements of each worker independently.



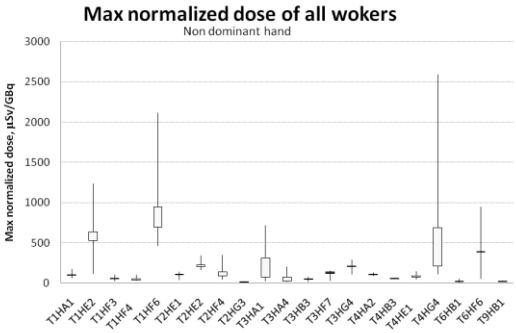


Figure 2: Example of box plot of all workers, hands independents. Procedure: Tc99m administration.

c. Dispersion plot. Mean maximum dose (mSv) vs mean manipulated activity (GBq).
N.B.: mean maximum dose is the mean value of the five maximum doses found among all measuring positions in each hand separately of each worker in mSv.

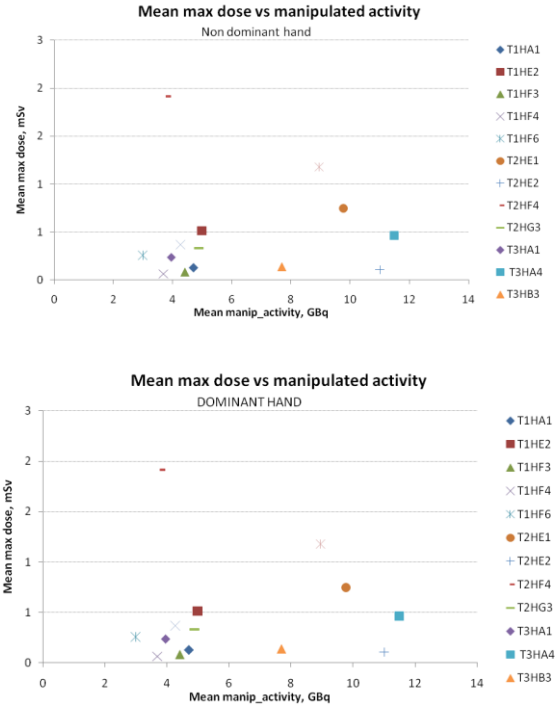


Figure 3: Example of dispersion plot. Procedure: Tc99m administration

d. Frequency of the position where the maximum dose is found for dominant and non dominant hand. Consider hands independently, so for each worker, you will have 2 maximum points, one in each hand. See Figure 4.
e. Plot of the cumulated maximum dose considering hands independents. In the x-axis the measuring positions (11) and in the y-axis the maximum cumulated normalized dose. (only add the dose value whenever it is the maximum of the 11 measuring points). See Figure 5.

N.B: To determine the maximum dose consider all measurements of one worker independently, not the mean value set in Table 5.

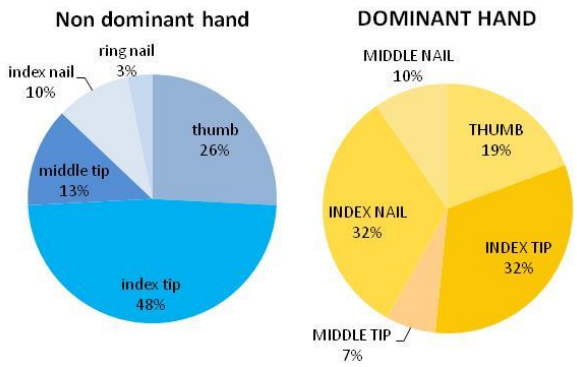


Figure 4: Example of plot for Frequency of the position where the maximum dose is found (hands independents).

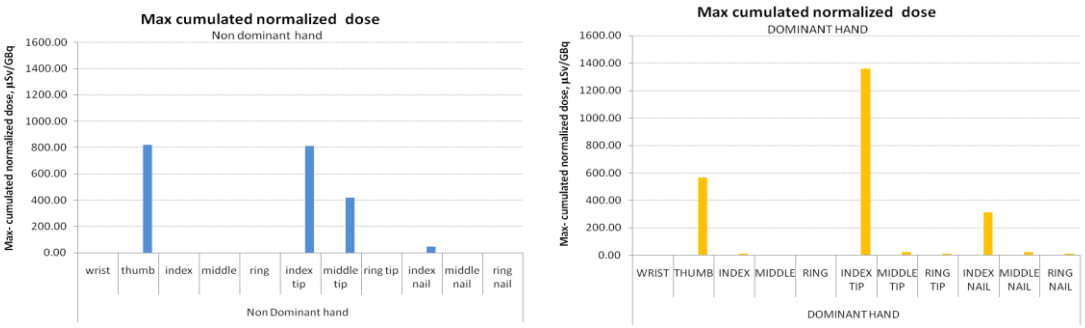


Figure 5: Maximum cumulated normalized dose. Hands independents

f. Frequency of the position where the maximum dose is found for dominant and non dominant hand. This time **consider hands together**, so you will have 1 maximum point per worker. See example in Figure 6.
N.B: To determine the maximum dose consider all measurements of one worker independently, not the mean value set in Table 5.

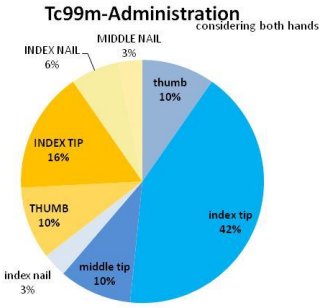


Figure 6: Example of plot for frequency of the position with max.dose. (hands together)

g. Plot of the cumulated maximum dose considering hands together. In the x-axis the measuring positions (22) and in the y-axis the maximum cumulated normalized dose. (only add the dose value whenever it is the maximum of the 22 measuring points). See example in Figure 7.

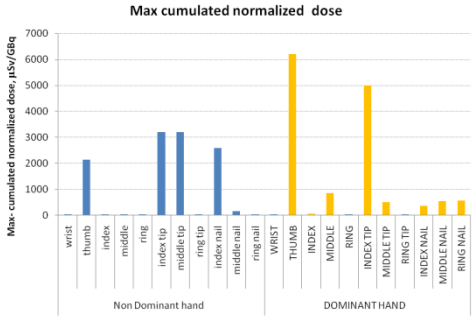


Figure 7: Maximum cumulated normalized dose. Example: Tc99m administration, database June2010

N.B: To determine the maximum dose consider all measurements of one worker independently, not the mean value set in Table 5.

h. Calculate the ratios of maximum dose with monitoring positions.
First complete the four next tables including the values of the followings ratios:
   - Ratio of Maximum: maximum dose of each measurement (among any of the TLD position and independently if it is situated in the dominant or non dominant hand) divided by:
     - ❖ the respective dose at the base of the ring finger of the non dominant hand; and do the same for dominant hand. Then, do the mean of this ratio by worker and complete Table 2 and Table 3
     - ❖ the respective dose at the wrist of the non dominant hand, and do the same for dominant hand. Then, do the mean of this ratio by worker and complete Table 2 and Table 3.
     - ❖ the respective dose at the base of the index of the non dominant hand, and do the same for dominant hand. Then, do the mean of this ratio by worker and complete Table 2 and Table 3.
     - ❖ the respective dose at the index tip, and do the same for dominant hand. Then, do the mean of this ratio by worker and complete Table 2 and Table 3.

Worker	Non Dominant hand			
	_____	_____	_____	_____
T1HA1	10	10	5	1
T1HE2	24	51	16	6
T1HF3	3	21	2	1
T1HF4	5	18	3	1
T2HE1	5	9	4	1
T2HE2	10	29	7	1
T2HF4	9	14	5	1
T2HG3	4	18	4	2
T3HA1	8	21	6	4
T3HA4	6	9	2	1
T3HG4	5	9	5	2
T4HA2	8	8	6	1
T4HE1	3	4	2	1
T4HG3	67	179	29	11
T4HG4	16	3	6	6

Table 2: Example of ratios for non dominant hand. Procedure: Tc99m administration.

Worker	DOMINANT HAND			
	_____	_____	_____	_____
T1HA1	20	7	10	7
T1HE2	17	40	8	1
T1HF3	4	8	2	1
T1HF4	6	10	4	1
T2HE1	11	16	8	6
T2HE2	11	27	6	2
T2HF4	16	30	9	5
T2HG3	11	19	8	3
T3HA1	8	11	4	1
T3HA4	6	10	5	2
T3HG4	6	9	4	2
T4HA2	15	23	13	6
T4HE1	4	7	3	1
T4HG3	83	115	59	30
T4HG4	18	21	14	6

Table 3: Example of ratios of maximum for dominant hand. Procedure: Tc99m administration.

Second, do one histogram with previous tables. See example in Figure 8.

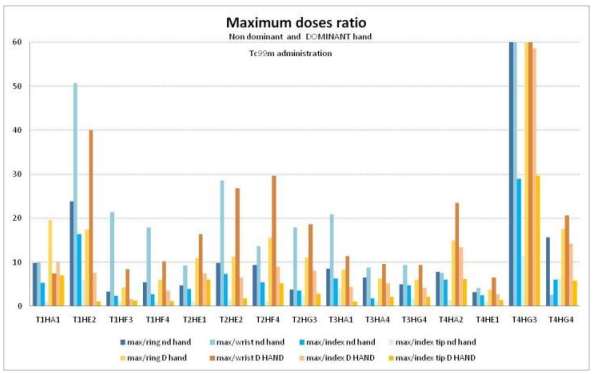


Figure 8: Example of ratios between maximum dose and dose in different legal and possible monitoring positions.

Then, do one box plot with previous ratios, like example in Figure 9.

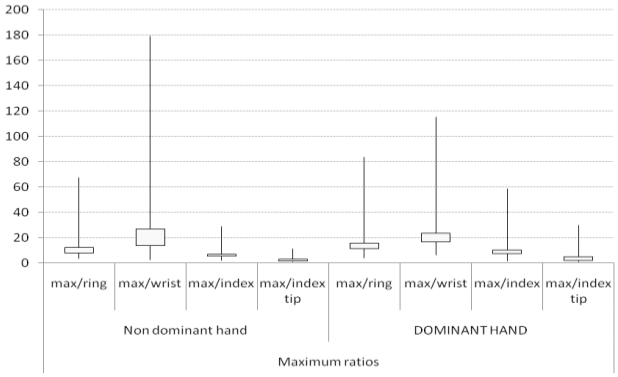


Figure 9: Example of box plot for doses ratio.

i. Histogram with mean dose per position separating by experience (where, low < 1year and high > 1year). Following Figure 10.

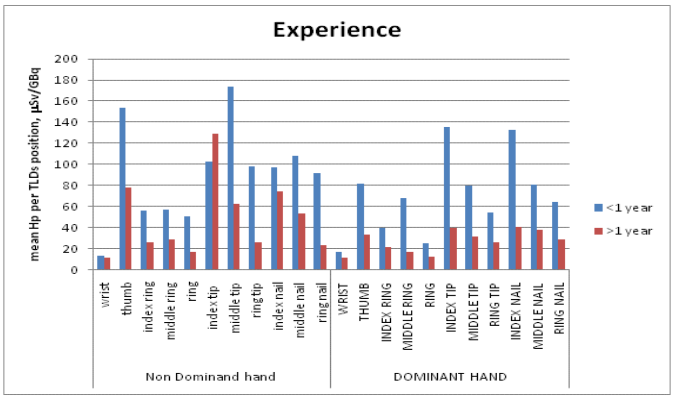


Figure 10: Example of experience histogram

j. Shielding bar plot. Average normalized dose vs tlds positions; where average dose is the mean dose of all workers; separating *use or not use* of shield. See example in Figure 11.

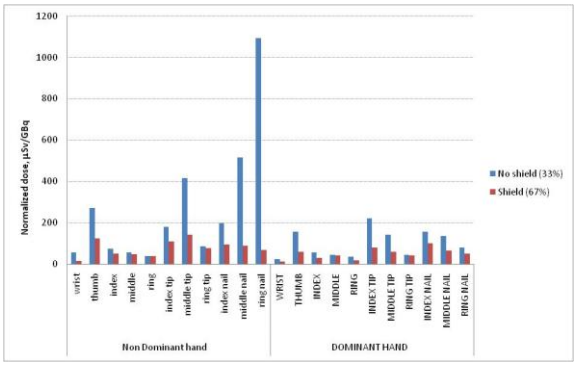


Figure 11: Example, evaluation of shield parameter

k. Extrapolation doses.

For each of your workers and for each radionuclide, calculate:

- Amanip/year (GBq): the mean manipulated activity per year for every technician for Tc99m and for F18 for each procedure.
- Max dose (µSv/GBq): is the maximum of the mean row in Table 5.
- Estimation of max annual dose (mSv): is (Amanip/year)*(Max dose)/1000
- % of annual limit considering separately the radionuclides

Then, to calculate worker's dose, add the estimations doses by radionuclide. Write in red if this result is bigger than 500mSv. See example in Table 4.

	Radionuclide-Procedure	Amanip/year (GBq)	Max dose (µSv/GBq)	Estimation of max annual dose (mSv)	% of annual limit considering only this radionuclide	Total max annual dose (mSv)
T1HA1	Tc99m-Labelling	1343.27	196.50	263.96	53%	609.99
	Tc99m-injection	61.15	107.03	6.55	1%	
	F18-labelling	186.16	1823.62	339.49	68%	
T3HA1	Tc99m-Labelling	809.90	849.16	687.74	138%	694.41
	Tc99m-injection	27.33	244.15	6.67	1%	

Table 4: Example estimation dose for Switzerland's workers

			Non Dominant hand Normalized dose [Hp(0.07)/Amanip] (uSv/GBq)											DOMINANT HAND Normalized dose [Hp(0.07)/Amanip] (uSv/GBq)										
worker	Mean Amanip (GBq)	Hp(0.07)	wrist	thumb	index	middle	ring	index tip	middle tip	ring tip	index nail	middle nail	ring nail	WRIST	THUMB	INDEX	MIDDLE	RING	INDEX TIP	MIDDLE TIP	RING TIP	INDEX NAIL	MIDDLE NAIL	RING NAIL
T1HA1	4.70	mean	10.80	63.15	19.94	14.64	10.90	107.03	54.99	20.53	51.26	60.14	16.18	14.44	10.34	10.74	7.56	5.46	15.40	25.80	24.07	13.92	13.73	13.26
		median	11.23	42.55	27.05	17.58	14.73	102.59	48.43	23.80	44.77	28.27	15.91	4.07	10.66	9.15	5.94	5.33	16.28	23.57	20.19	13.89	15.54	14.21
		minimum	0.00	25.59	3.16	0.00	0.00	60.94	22.64	2.29	28.41	21.34	2.98	0.00	0.00	0.00	0.00	0.00	0.00	21.15	6.59	10.91	3.11	0.00
		maximum	22.21	147.89	31.93	24.96	18.21	177.60	103.05	35.20	73.21	171.90	32.05	56.99	20.09	25.59	22.56	10.70	24.94	31.40	47.47	16.72	20.21	23.10
		std dev	8.21	49.84	12.55	9.64	7.45	45.04	30.84	12.47	20.41	63.59	11.40	24.22	7.13	9.78	8.87	3.89	9.33	4.70	15.45	2.15	6.47	8.33
T1HE2	4.99	mean	12.61	112.82	39.18	29.84	26.88	105.04	57.65	34.77	67.06	36.68	30.74	15.98	305.97	84.41	48.04	36.59	639.44	84.57	42.46	271.37	133.69	50.42
		median	11.09	114.09	42.40	30.67	25.30	108.88	56.01	34.94	64.30	38.81	30.57	15.70	236.02	90.72	44.96	35.48	528.06	85.84	45.06	265.07	142.53	55.86
		minimum	8.83	35.01	23.97	20.36	18.60	29.83	21.91	24.02	16.80	13.76	16.04	11.20	47.51	33.45	21.41	19.24	116.35	30.93	20.74	66.57	46.92	19.75
		maximum	18.86	168.65	47.46	37.06	33.31	195.87	99.90	43.47	119.69	49.29	42.36	20.84	817.30	110.11	66.00	55.27	1239.47	122.46	59.39	410.49	190.94	65.17
		std dev	3.86	49.29	9.20	6.11	6.35	64.70	27.97	7.05	36.49	13.57	9.58	3.66	296.62	29.85	17.98	12.85	452.97	34.79	14.35	133.20	54.64	18.20
T1HF3	4.41	mean	1.90	38.31	16.86	14.40	12.42	40.54	34.66	18.71	22.21	18.05	15.72	4.80	24.36	24.59	11.60	9.57	30.34	16.44	16.71	27.78	16.88	13.72
		median	1.34	22.61	10.78	7.68	8.29	24.54	15.55	12.55	12.97	14.46	11.91	2.68	9.94	6.83	4.49	5.08	15.52	11.76	9.49	16.25	10.70	12.48
		minimum	0.00	8.29	6.17	4.45	3.97	21.82	9.14	8.50	6.08	6.37	4.16	1.55	3.84	2.07	1.96	0.00	6.23	1.72	2.60	7.28	2.93	3.10
		maximum	4.86	83.79	45.98	42.14	29.50	90.14	89.10	45.35	60.22	39.34	29.93	13.71	88.13	99.95	41.39	33.58	103.04	46.55	52.98	85.56	48.61	30.35
		std dev	2.13	31.53	16.52	15.80	10.48	29.07	34.11	15.14	22.41	12.85	10.14	5.09	35.81	42.18	16.73	13.59	40.82	17.49	20.54	32.55	18.11	10.25
T1HF4	3.68	mean	2.07	15.85	13.68	9.73	6.83	37.07	30.59	11.55	29.44	20.49	6.19	3.64	24.72	10.54	8.55	6.15	30.42	17.49	10.30	34.76	26.30	14.79
		median	1.38	7.77	8.89	4.31	3.14	33.46	8.15	2.44	19.56	16.13	3.60	2.68	25.81	11.95	8.34	6.56	25.13	16.14	10.81	35.97	24.46	12.07
		minimum	0.00	3.52	2.96	0.00	0.00	10.37	0.00	0.00	14.93	10.43	0.00	0.00	19.59	6.06	6.90	5.16	20.82	12.46	8.59	27.12	11.68	10.49
		maximum	5.78	51.53	42.03	36.20	25.89	78.59	107.92	50.32	76.33	46.69	17.11	8.45	29.62	14.93	11.14	6.91	52.10	23.25	11.96	45.30	42.15	24.40
		std dev	2.45	20.21	16.11	14.96	10.74	25.52	44.52	21.77	26.29	14.86	6.66	3.22	3.77	3.71	1.69	0.78	12.70	4.17	1.50	7.11	11.75	5.79
T1HF6	2.99	mean	1.75	80.82	27.91	12.81	8.05	147.84	52.67	11.59	52.91	22.08	9.20	4.18	938.47	47.18	30.20	17.39	515.22	357.44	40.82	209.41	126.26	42.94
		median	1.95	84.56	22.52	13.89	7.59	144.72	35.71	9.54	56.44	21.58	8.32	4.75	695.97	40.96	24.34	17.57	442.81	391.07	40.61	75.83	110.58	43.97
		minimum	0.00	52.53	15.72	8.17	4.06	46.97	20.34	8.86	39.77	16.04	6.28	0.00	401.32	19.13	18.41	9.47	369.24	217.17	32.34	70.42	87.83	26.32
		maximum	4.83	107.34	41.66	16.09	12.91	313.02	96.21	19.60	68.86	29.11	16.12	7.68	2112.42	108.05	54.79	25.98	795.23	464.24	52.50	679.39	173.11	60.58
		std dev	1.98	23.52	11.08	3.05	3.28	104.12	36.37	4.53	11.87	5.70	4.04	2.78	679.52	35.53	15.08	5.88	179.48	100.89	8.00	264.88	37.62	13.32
T2HE1	9.77	mean	10.12	61.84	24.24	20.52	19.78	93.41	41.36	20.22	56.12	58.14	23.85	5.69	15.90	12.44	11.10	8.57	15.47	12.90	10.58	21.08	14.30	11.87
		median	10.48	66.41	26.21	20.21	18.51	102.02	39.86	20.79	59.86	42.81	25.22	5.77	14.96	13.38	11.38	8.26	16.28	13.00	10.79	21.50	15.18	13.26
		minimum	8.84	31.21	17.03	15.09	14.20	36.20	30.98	13.75	31.40	24.29	15.00	3.58	11.15	8.23	7.18	5.49	8.32	9.50	5.78	10.20	7.60	6.41
		maximum	11.73	76.84	28.47	25.69	24.15	143.00	64.40	24.32	70.07	131.97	28.82	7.70	20.42	15.46	14.00	11.17	18.59	15.68	14.27	28.21	17.64	14.66
		std dev	1.24	17.72	4.76	3.88	4.20	39.59	13.62	4.04	15.67	42.37	5.21	1.62	4.28	2.77	2.53	2.23	4.12	2.22	3.06	7.06	3.95	3.22
T2HE2	11.00	mean	7.06	201.85	27.58	21.44	20.41	137.35	100.20	46.19	135.36	67.32	46.19	7.52	71.52	31.15	22.12	18.02	113.45	66.22	42.59	115.67	76.92	54.10
		median	7.96	194.75	26.61	20.61	17.52	162.90	95.64	45.71	129.68	67.92	43.73	9.46	77.74	34.55	22.59	17.09	102.33	62.04	28.79	67.33	86.66	43.23
		minimum	3.37	105.93	23.18	13.86	15.81	0.00	68.93	34.74	90.02	43.89	33.70	3.13	33.05	13.36	9.46	8.24	29.44	31.95	20.83	32.37	39.29	18.20
		maximum	9.72	342.42	34.01	27.92	25.87	233.65	134.44	57.72	197.44	92.29	61.42	10.43	110.72	49.12	36.74	29.32	224.19	103.18	88.36	256.21	115.45	130.10
		std dev	2.66	87.44	4.19	5.27	4.95	89.85	27.72	9.17	39.67	18.13	10.17	3.48	37.16	15.68	11.59	8.92	87.52	31.82	27.89	91.52	34.74	45.69
T2HF4	3.78	mean	8.11	83.52	20.52	18.64	11.87	110.74	36.30	22.67	104.49	38.16	28.79	3.74	10.65	12.37	13.80	7.12	21.05	12.28	8.39	24.48	10.48	9.22
		median	7.34	68.33	24.54	20.66	14.29	54.85	32.89	24.96	91.28	39.80	27.15	4.10	6.80	11.18	8.79	6.43	12.91	7.78	6.09	13.96	8.01	6.37
		minimum	3.30	27.89	5.94	7.76	0.00	25.14	7.78	5.18	45.74	15.14	6.94	0.00	3.57	5.20	3.43	3.23	5.96	3.48	3.43	3.21	0.00	3.92
		maximum	15.81	216.82	32.96	26.34	19.34	346.97	62.95	34.97	173.89	62.30	59.16	9.43	27.46	28.46	27.25	14.55	61.78	25.54	18.84	77.07	28.90	22.59
		std dev	4.69	77.17	10.75	7.97	7.52	134.05	20.22	10.93	58.06	18.73	19.46	3.95	9.96	9.45	10.41	4.46	23.10	9.41	6.23	29.94	10.98	7.56
T2HG3	4.89	mean	10.26	12.30	10.26	10.26	10.26	12.38	10.26	10.26	10.26	10.26	10.26	10.26	10.26	10.26	10.26	10.26	10.26	10.26	10.26	12.38	10.26	10.26
		median	10.17	10.56	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17	10.17
		minimum	9.48	9.48	9.48	9.48	9.48	9.48	9.48	9.48	9.48	9.48	9.48	9.48	9.48	9.48	9.48	9.48	9.48	9.48	9.48	9.48	9.48	9.48
		maximum	11.31	20.34	11.31	11.31	11.31	21.13	11.31	11.31	11.31	11.31	11.31	11.31	11.31	11.31	11.31	11.31	11.31	11.31	11.31	21.13	11.31	11.31
		std dev	0.71	4.55	0.71	0.71	0.71	4.94	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	4.94	0.71	0.71
T3HA1	3.95	mean	11.67	113.18	38.99	36.05	28.83	61.23	88.97	54.61	53.44	88.73	73.85	21.52	77.83	55.13	188.34	29.51	244.15	93.26	45.35	54.89	37.72	36.80
		median	5.56	27.94	20.01	14.45	10.69	34.37	50.36	19.05	24.45	30.94	34.89	16.40	40.93	31.70	22.79	11.23	59.78	26.23	27.60	32.83	22.43	33.90
		minimum	0.00	5.93	6.89	0.00	8.08	10.88	5.18	13.54	15.39	1.08	0.00	0.00	4.27	-1.67	0.00	5.65	3.63	-1.18	3.44	9.13	2.68	9.95
		maximum	25.70	379.00	83.90	90.11	65.40	154.77	280.00	131.17	110.15	272.72	236.83	51.45	234.46	192.88	714.17	73.42	688.99	341.82	97.66	173.80	108.28	77.83
		std dev	11.26	156.31	33.80	38.57	26.79	60.10	111.63	53.43	45.95	113.04	96.61	23.12	90.95	78.76	304.95	29.65	307.69	142.42	40.97	67.58	42.77	29.02
T3HA4	11.49	mean	6.67	38.33	32.80	14.39	8.99	58.26	14.28	11.29	46.25	16.43	13.03	6.08	10.36	11.27	28.13	9.27	28.06	24.60	14.65	20.11	32.21	12.50
		median	6.88	21.58	11.52	10.85	10.42	24.26	13.33	11.15	20.77	15.44	13.62	4.67	7.06	13.15	9.16	9.28	11.97	10.61	9.04	8.01	9.26	9.86
		minimum	3.83	13.42	6.93	6.46	1.12	13.31	6.02	4.95	18.35	9.71	5.45	2.57	5.42	4.18	4.84	6.19	5.68	5.36	6.69	5.90	7.25	6.59
		maximum	10.68	108.68	115.91	30.63	16.52	204.87	23.35	19.42	140.67	23.93	20.16	10.55	17.09	17.08	105.13	13.31	93.90	62.55	30.31	57.31	82.87	19.50
		std dev	2.60	40.18	46.69	10.00	5.84	82.47	6.94	6.09	53.04	5.32	5.64	3.80	5.58	5.47	43.20	2.80	37.09	24.26	9.93	21.80	34.25	6.23

Table 5: Results of normalized doses for each worker with at least 4 measurements. Procedure: Tc99m-administration.