



EXTREMITY EXPOSURE IN DIAGNOSTIC NM WITH ^{18}F AND $^{99\text{m}}\text{Tc}$ LABELLED RADIOPHARMACEUTICALS.

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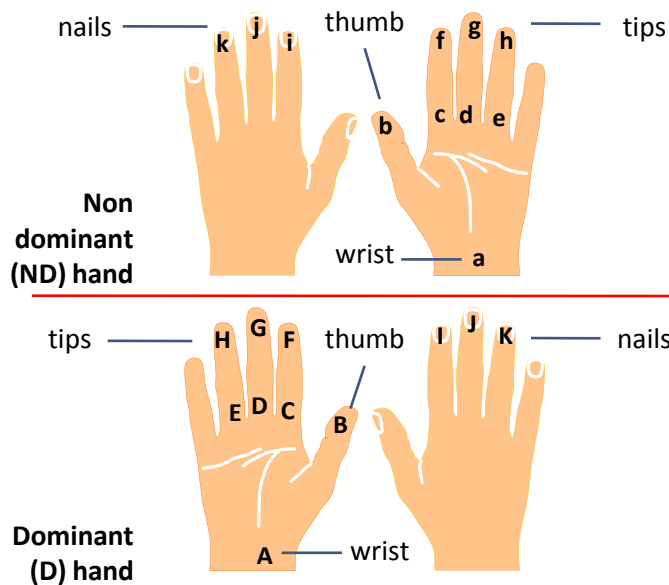
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Collected and analyzed data

- Preparation and administration separately
- 22 positions of measurement
- Workers with at least 4 measurement series
- Mean measurement per worker

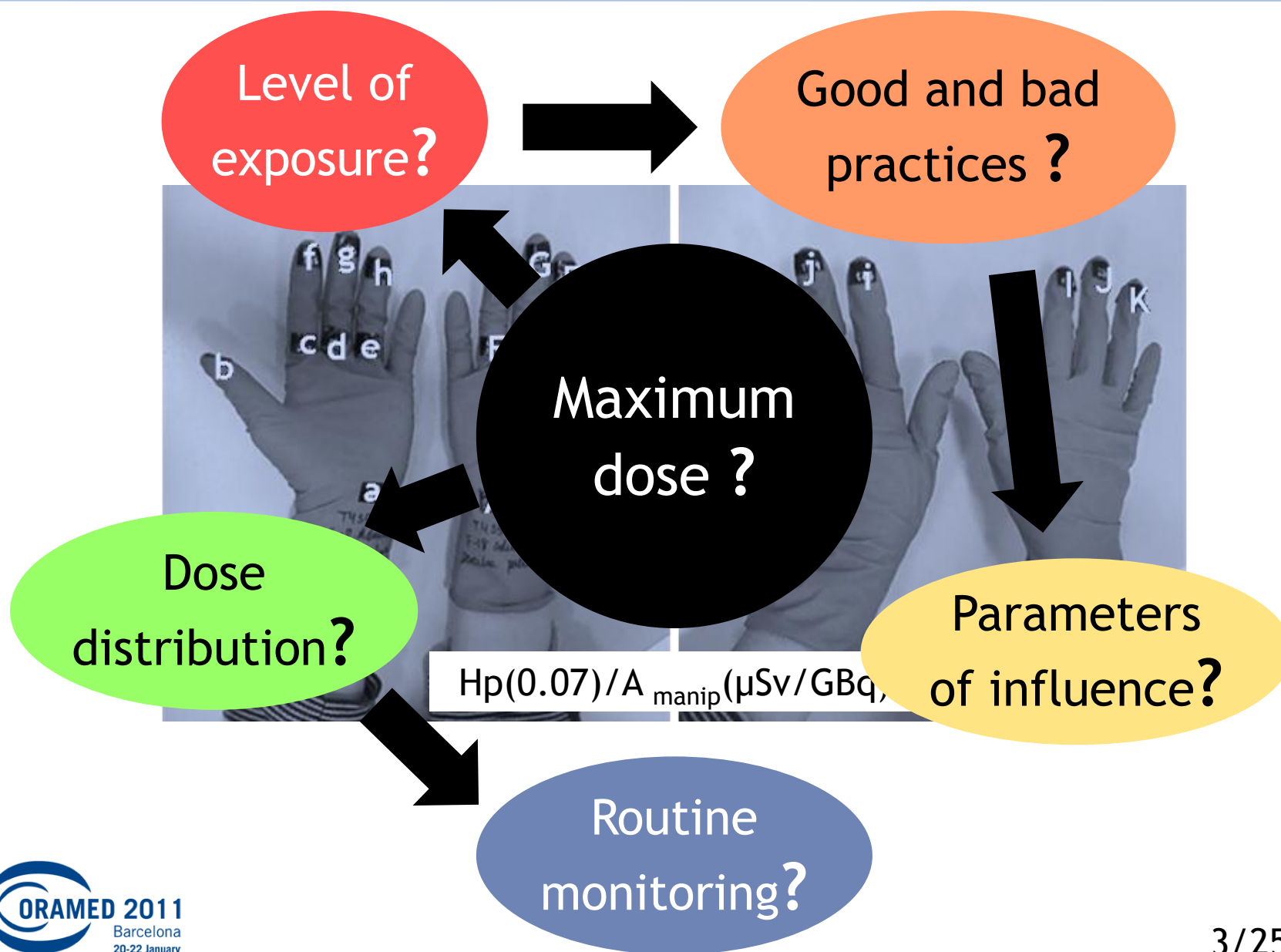


Measurements included in the analysis

	Number of NM departments	Number of workers	Number of measurements
Tc-99m preparation	21	36	178
Tc-99m administration	20	32	157
F-18 preparation	17	30	160
F-18 administration	17	30	146

Large number of monitored workers following a common measurement protocol.

Objectives of the analysis



Difficulties and limitations of the study

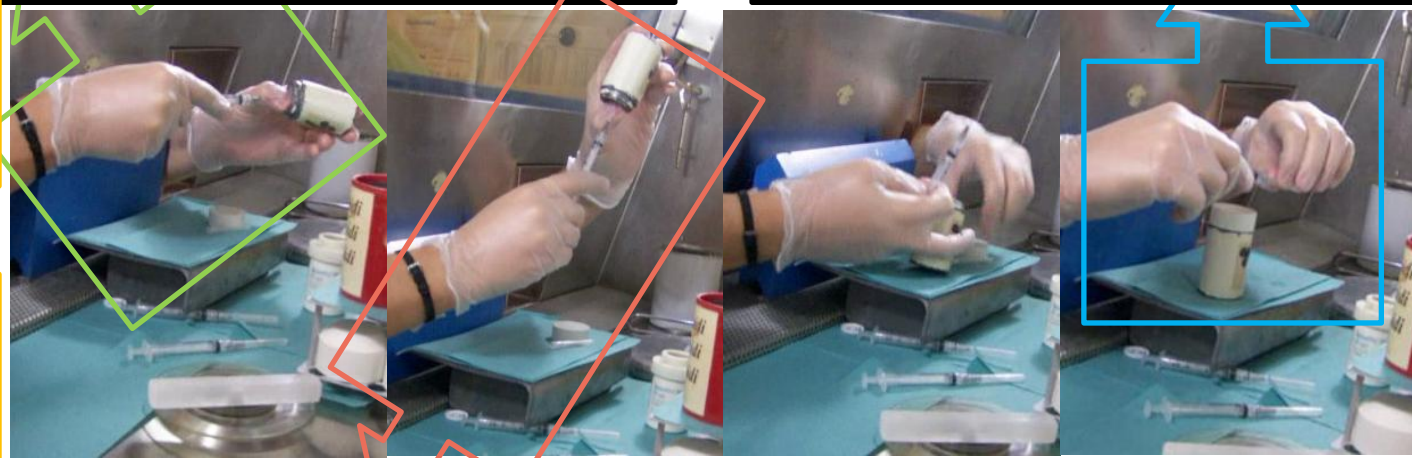
Individual
working habits



Operation
time



Shielding

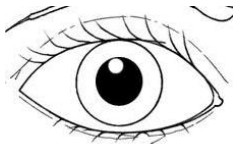


Measurements
performance

Manipulated
activity

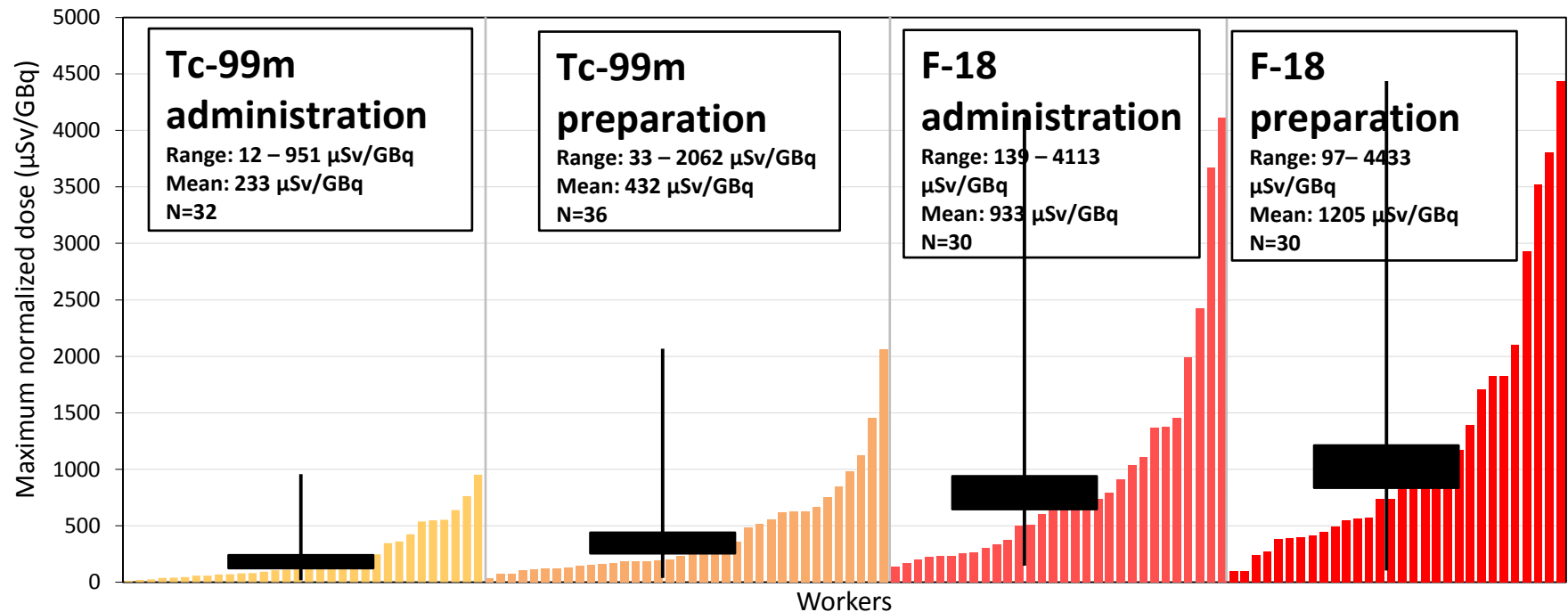
Parameters
and steps

Not recorded
parameters



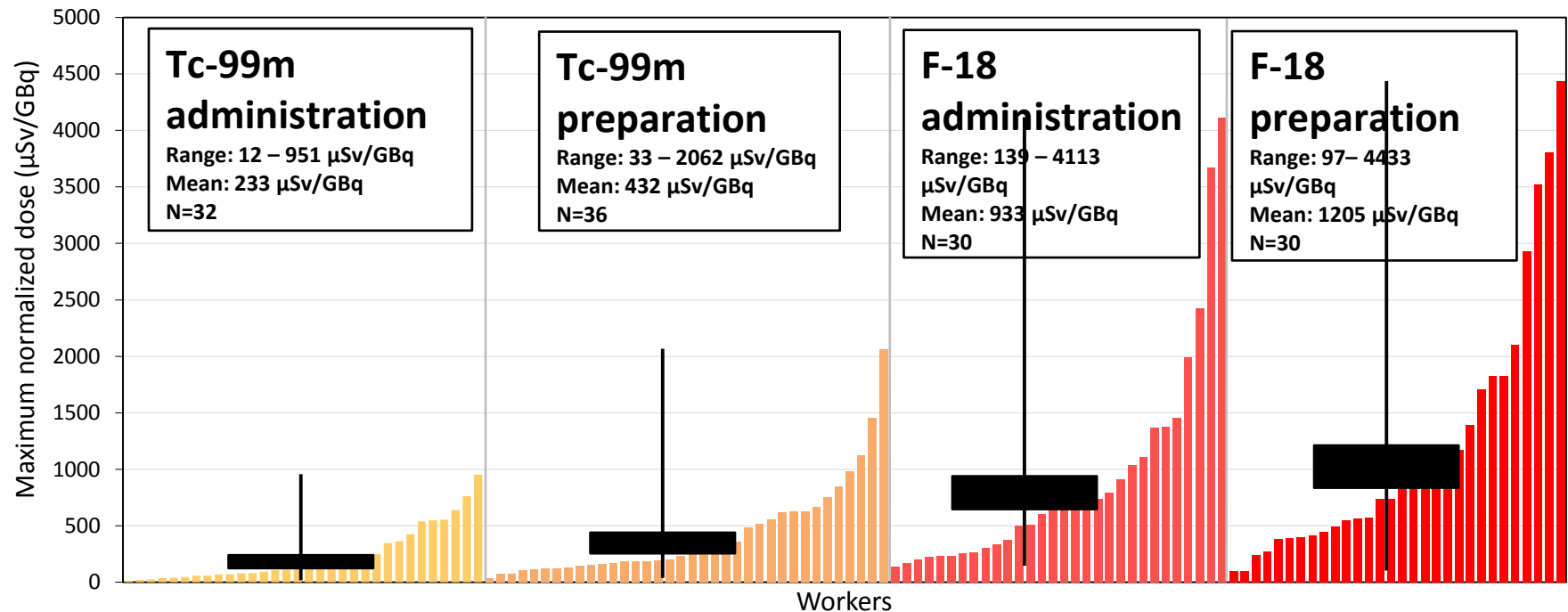
The characteristics of the measurements make it not possible to study parameters in detail, but an overall general reality. MC simulation was used to complete the study in this sense*.

Overview on finger doses in diagnostic NM



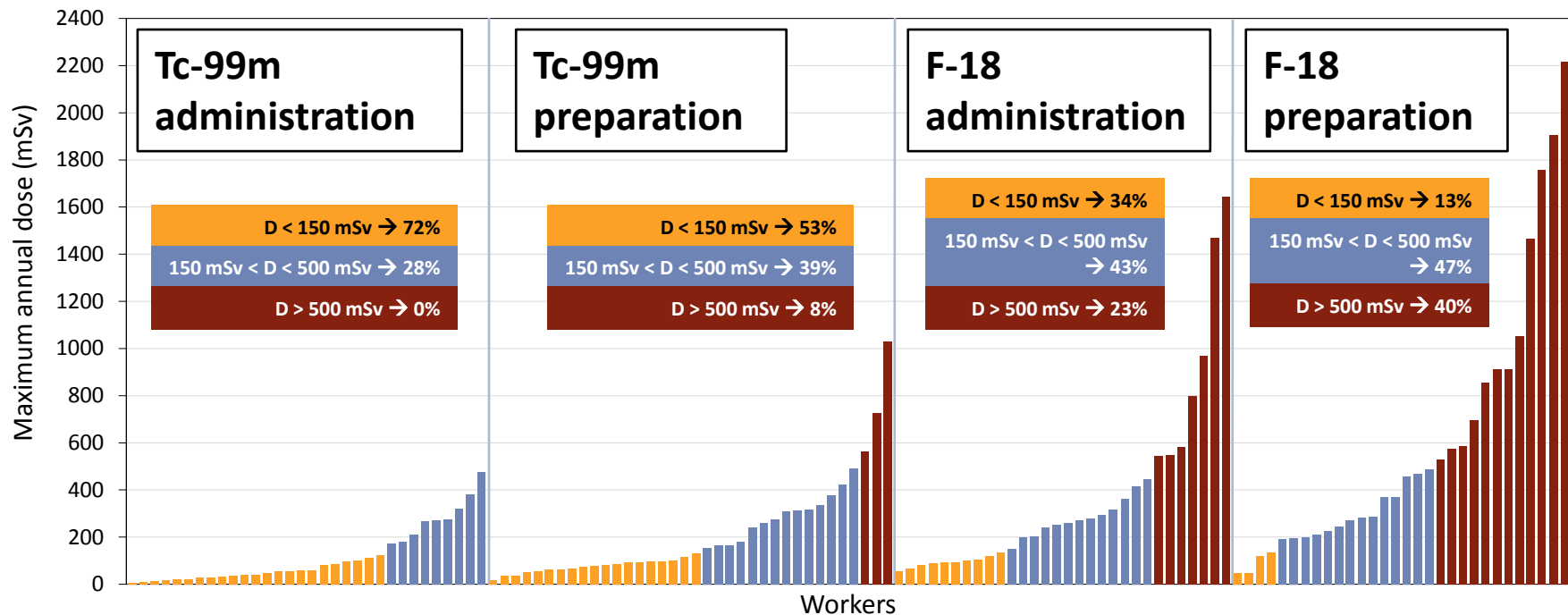
- Very large range of maximum finger doses among the same procedure.
- The preparation of the radiopharmaceutical involves higher finger doses per activity than the administration.
- F-18 involves higher finger doses per activity than Tc-99m.
- The preparation of F-18 is the most critical among the studied diagnostic procedures.

Overview on finger doses in diagnostic NM



→ Are these finger doses a matter of concern from the point of view of radiation protection ?

Critical exposures ? Numerical exercise

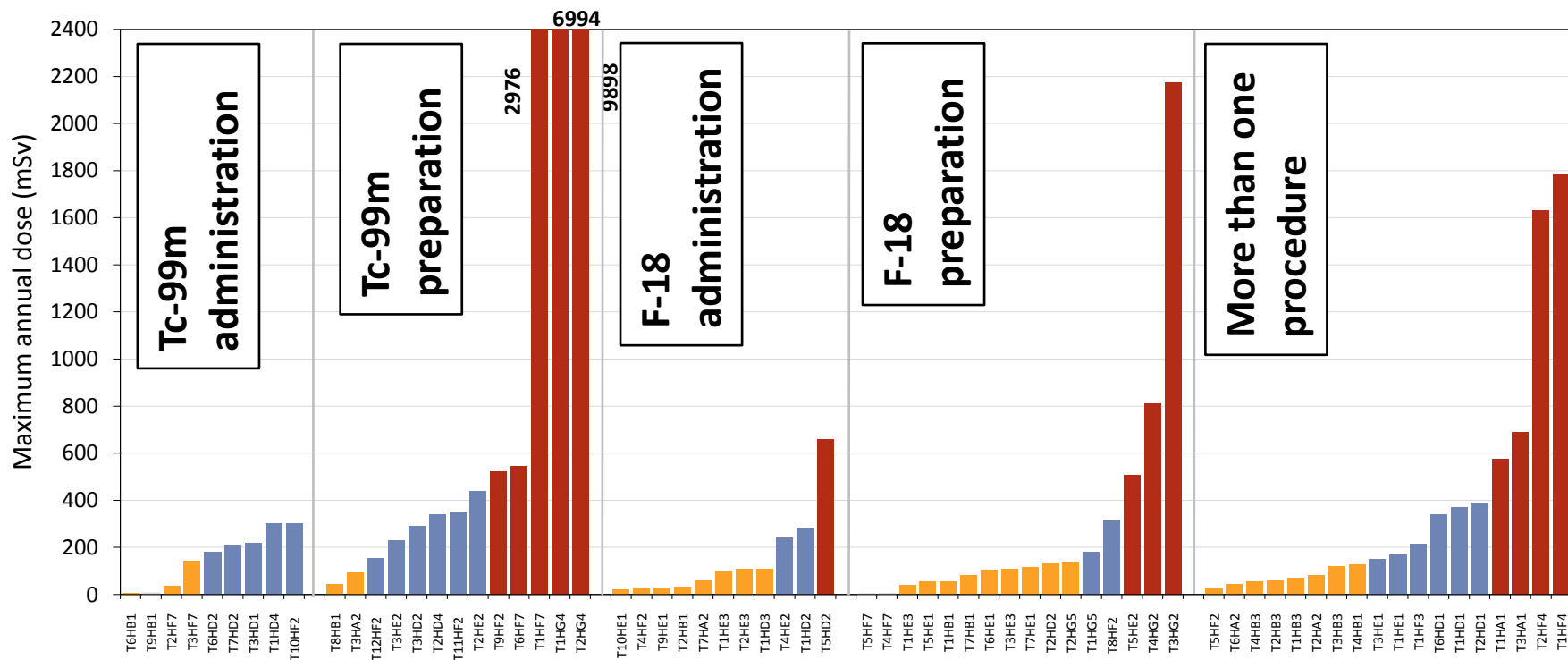


Procedure	Range (μSv/GBq)	Mean (μSv/GBq)	Patients per year	Activity per patient (MBq / mCi)
Tc-99m administration	12 - 951	233	1000 (5 patients per day, 10 months)	100 - 850 / 3 - 30 Mean: 500 / 14
Tc-99m preparation	33 - 2062	432		
F-18 administration	139 - 4113	933		400 / 11
F-18 preparation	97 - 4433	1205		500 / 14

Considering all procedures

D < 150 mSv → 44%
150 mSv < D < 500 mSv → 39%
D > 500 mSv → 17%

Annual dose estimation



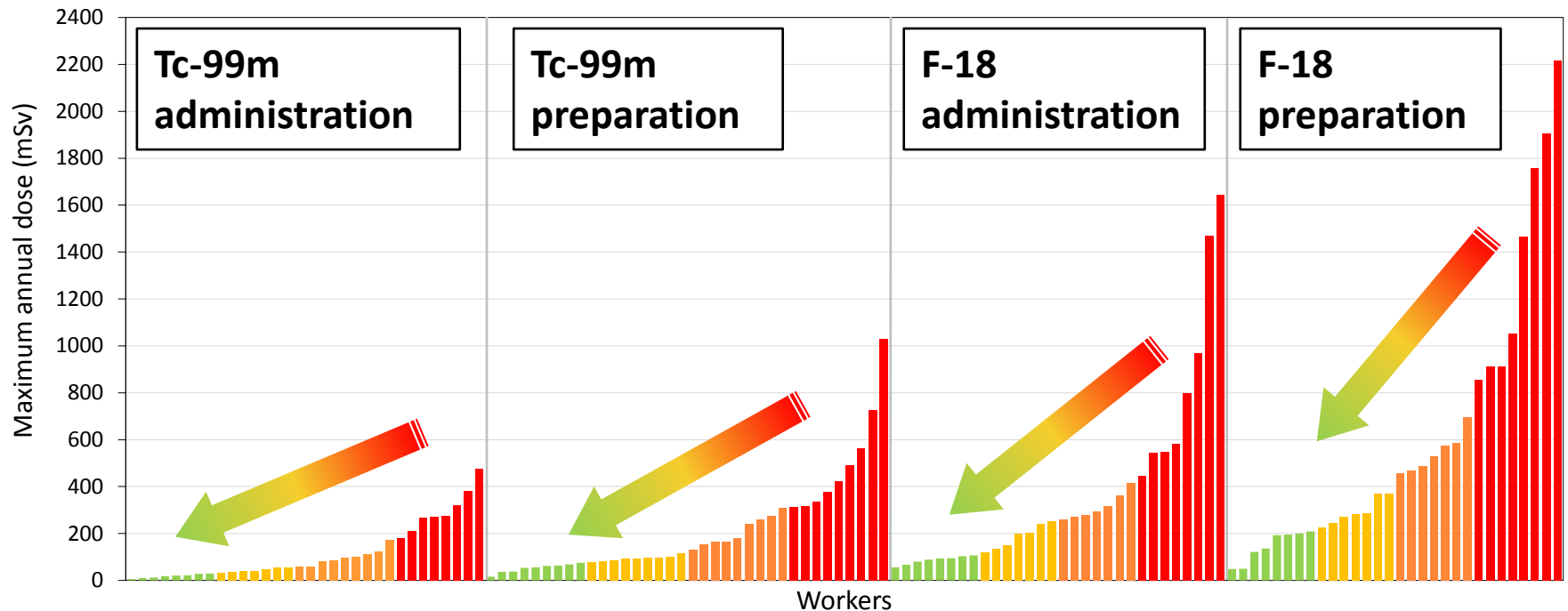
$D < 150 \text{ mSv} \rightarrow 49\%$

$150 \text{ mSv} < D < 500 \text{ mSv} \rightarrow 31\%$

$D > 500 \text{ mSv} \rightarrow 19\%$

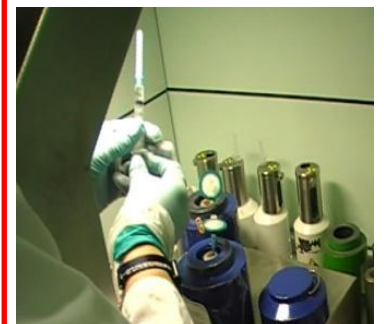
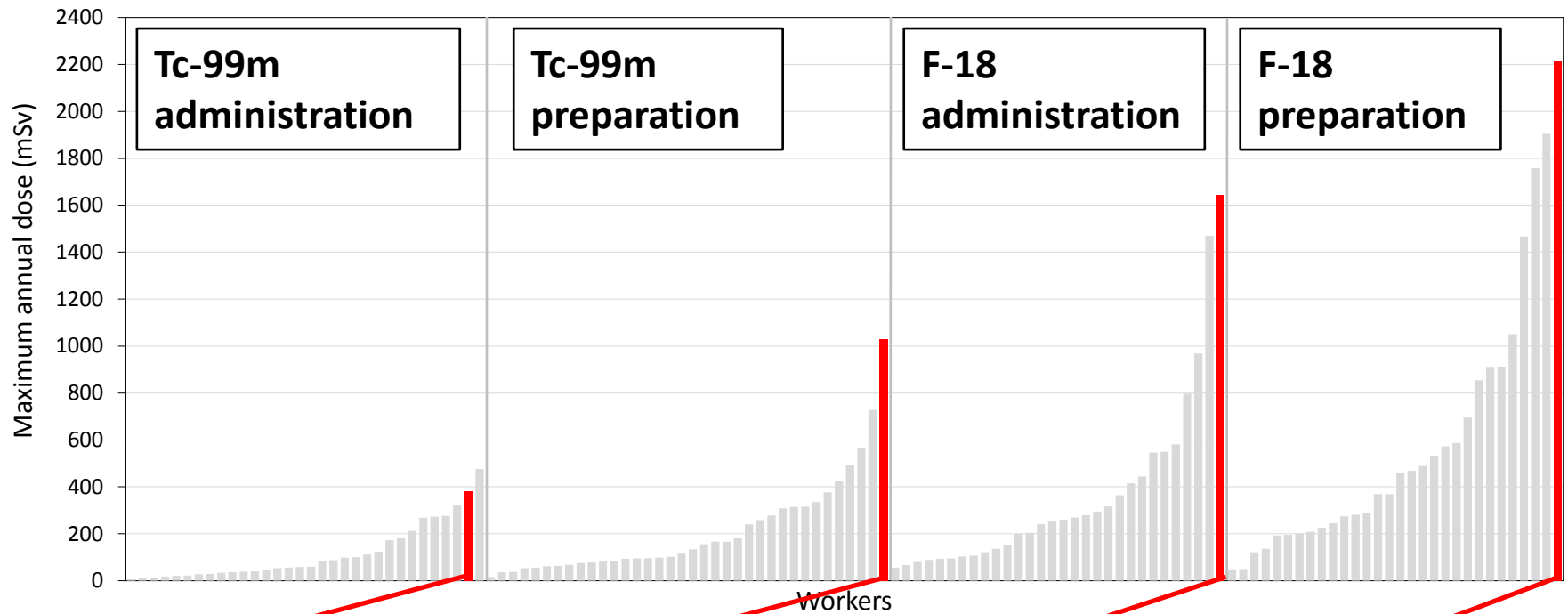
- Some workers were monitored for only one type of procedure for the ORAMED project when actually they performed more. In these cases, the estimation of the annual dose has been calculated only considering the monitored procedures, from which real measured values were available.
- Even considering this hypothesis, it is found that the extrapolated doses reach the annual limit for 19%.

Potential to further decrease exposures?

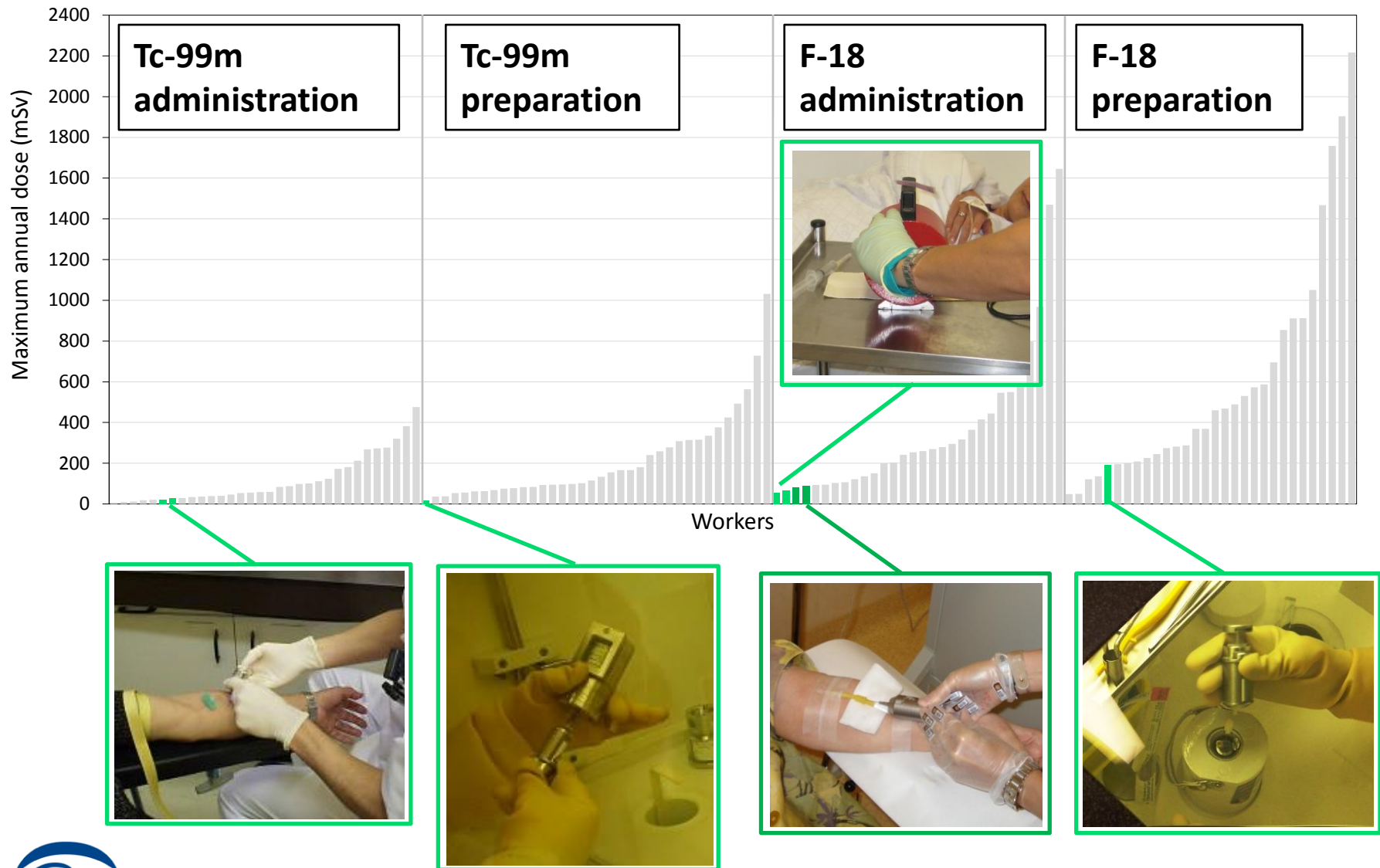


High and low doses are linked to bad and good practices, respectively, hence...

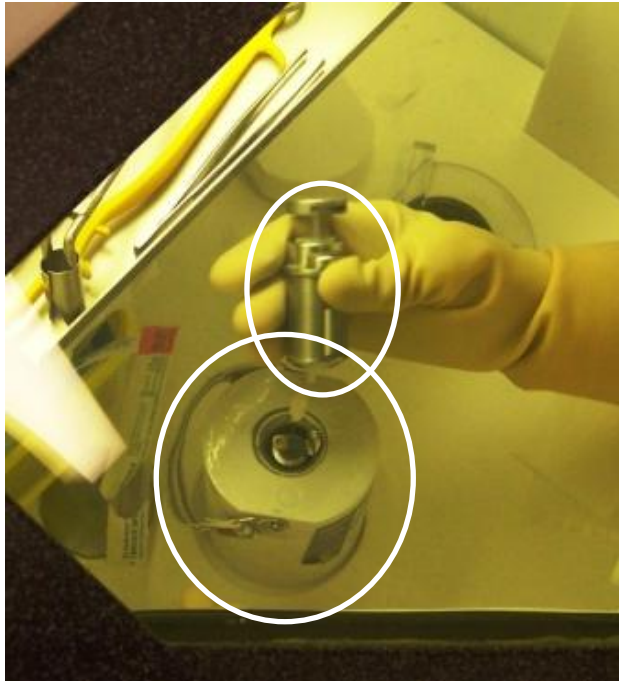
Bad practices



Good practices



Parameters of influence ?



Vial shield
(Y/N)



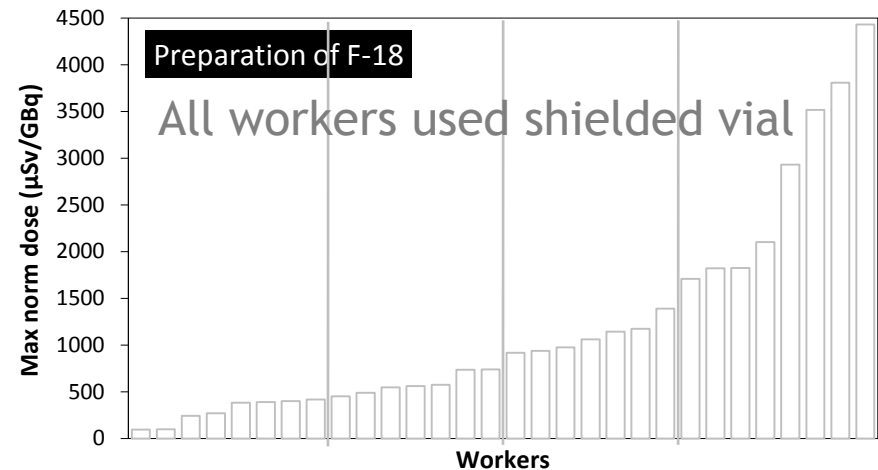
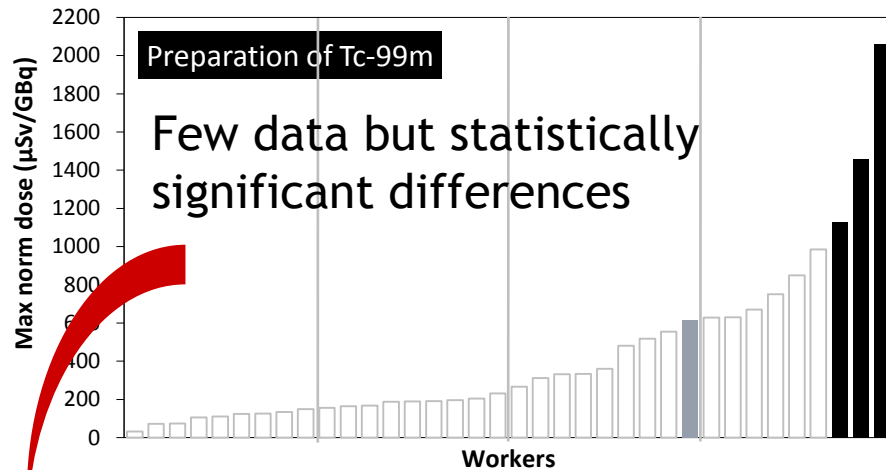
Syringe shield
(Y/N)

Worker experience
(> 1 year / ≤ 1 year)

→ **Statistical tests:** Mann-Whitney *U* test (non-parametric) to study the differences between the dose received...

- ... by workers using **shielded** and **unshielded** syringe/vial?
- ... by **beginners** (1 year or less experience) and **experienced** (more than 1 year experience) workers?

Vial shield: higher doses with unshielded vial?

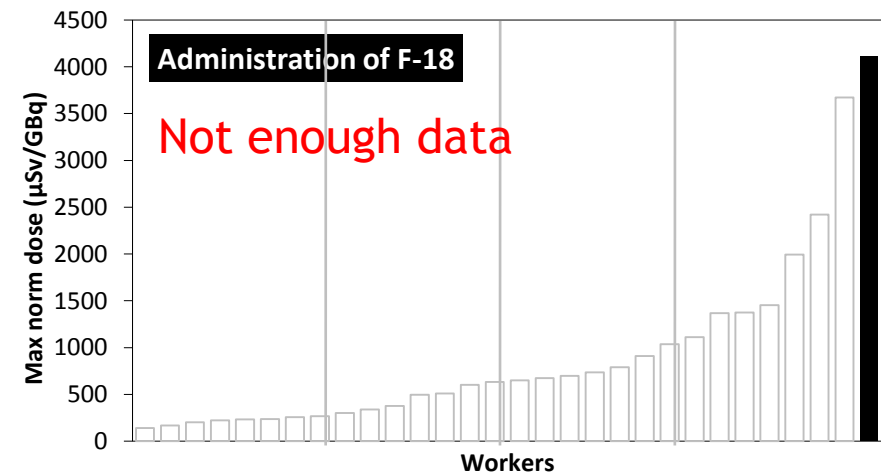
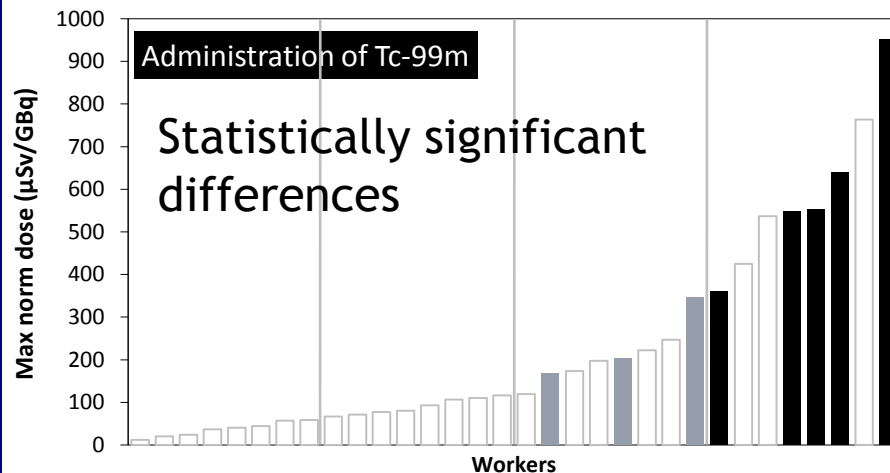
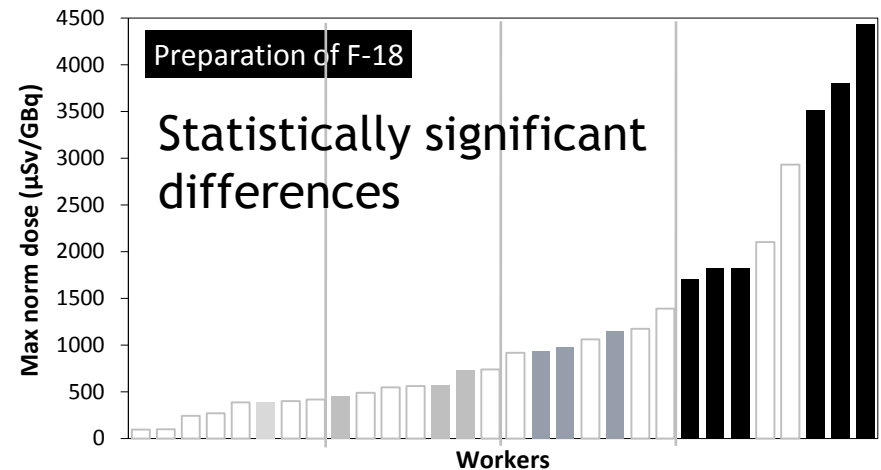
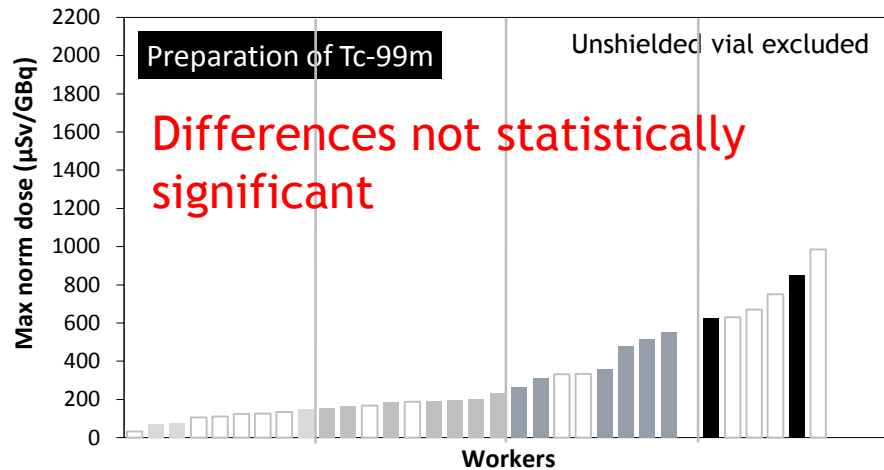


When using an unshielded vial,

- ND hand receives significantly higher doses in all positions except the wrist with unshielded vial and
- D hand receives significantly higher dose on the index and middle tip than when using a shielded vial



Syringe shield: higher doses with unshielded syringe?

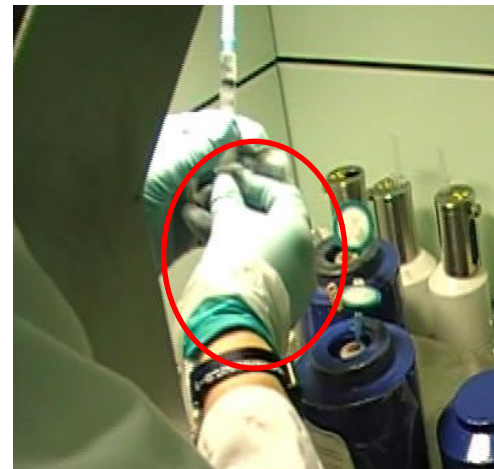
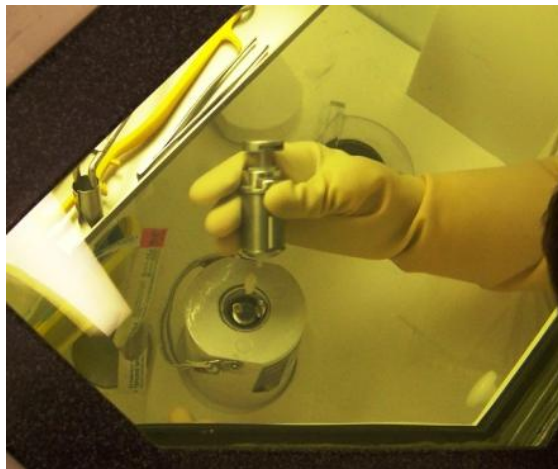


Syringe shield

F-18 preparation

When using an unshielded syringe,

- ND hand receives significantly higher doses at the thumb and base of the index and
- D hand receives significantly higher doses at all positions except the base of the ring and wrist than when the syringe is shielded.

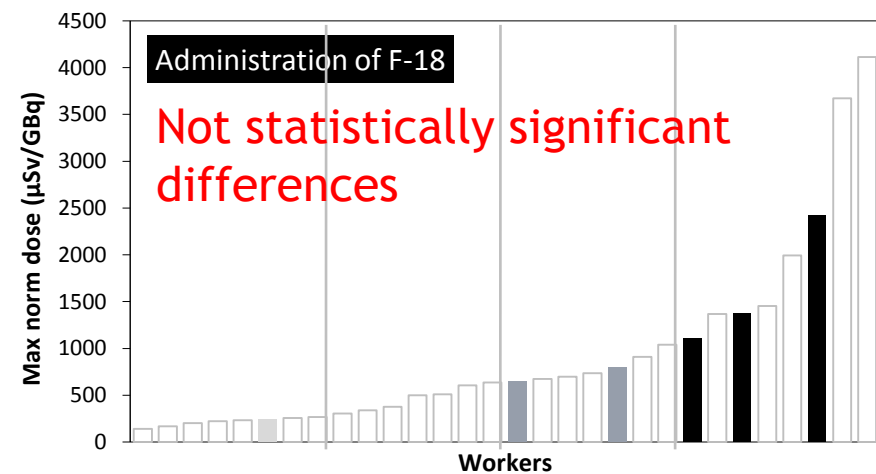
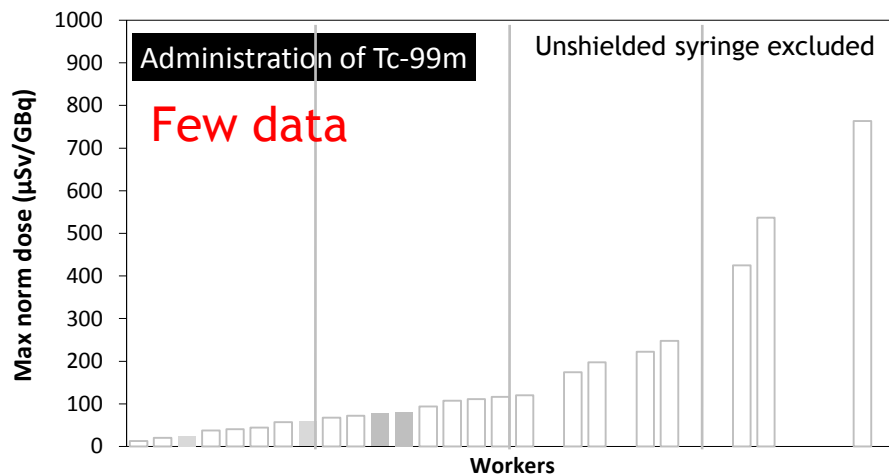
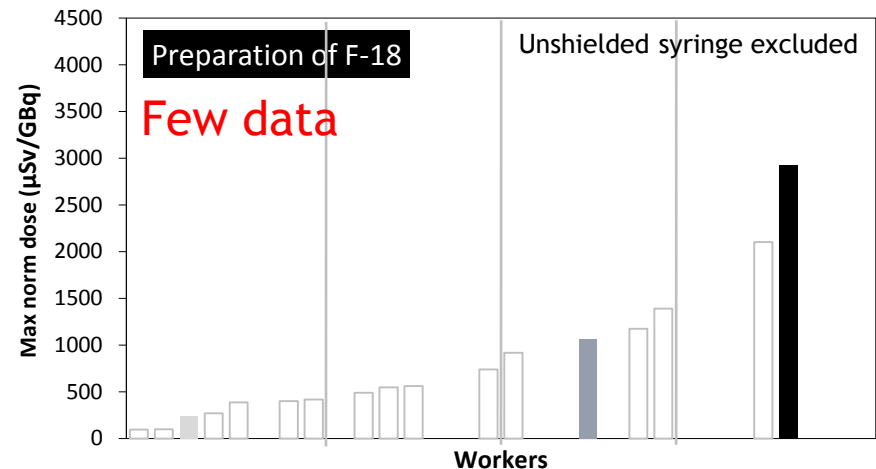
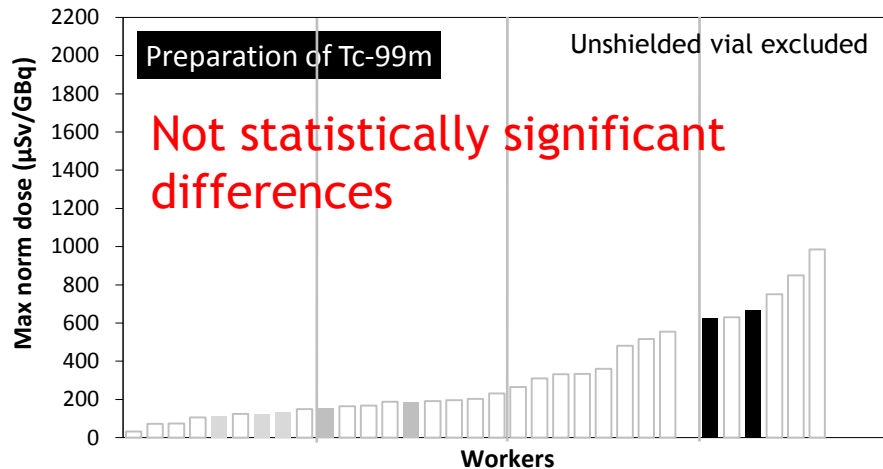


Tc-99m administration

When using an unshielded syringe, both hands receive significantly higher doses in almost all positions than when the syringe is shielded.



Experience: higher doses for beginners ?



→ The influence of the experience on the dose is not clear (few data, influence overlapped with other parameters).

Identified parameters of influence

Data is analyzed in further steps dividing into groups taking into account the identified parameters of influence



4 workers, 11%

Preparation of
Tc-99m

Vial shield



32 workers, 89%



13 workers, 43%

Preparation of F-18

Syringe shield



17 workers, 57%



8 workers, 27%

Administration of
Tc-99m

Syringe shield

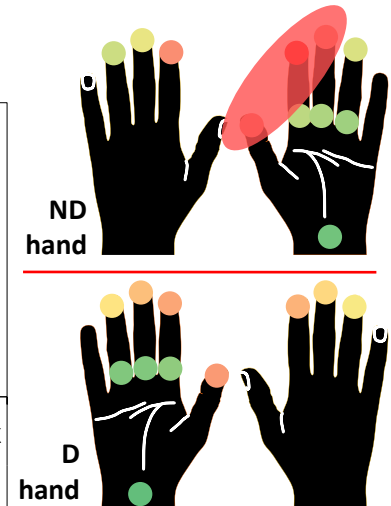
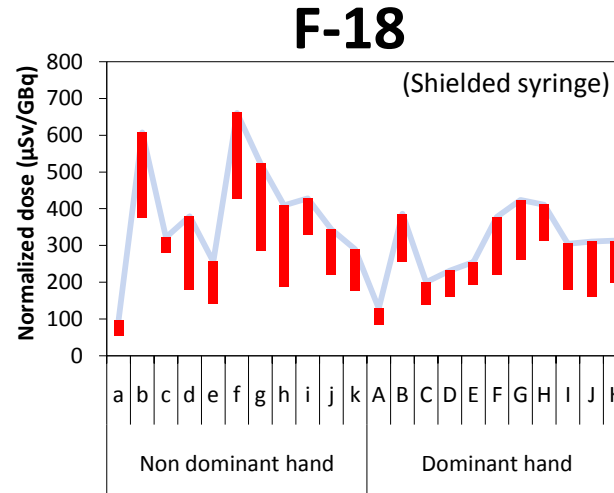
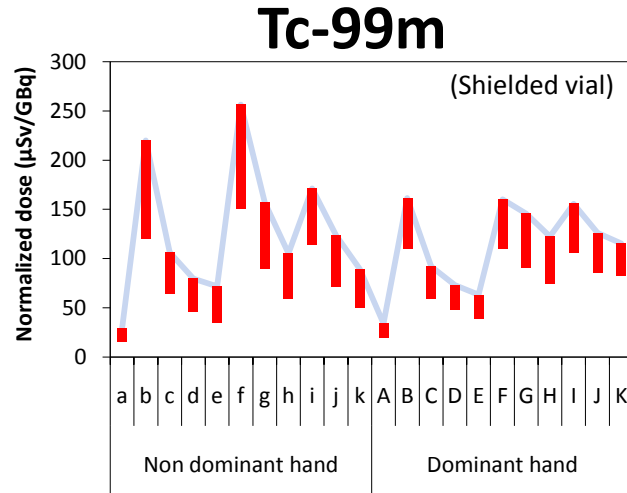


22 workers, 73%

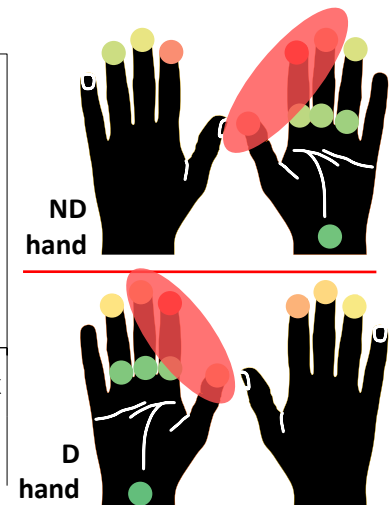
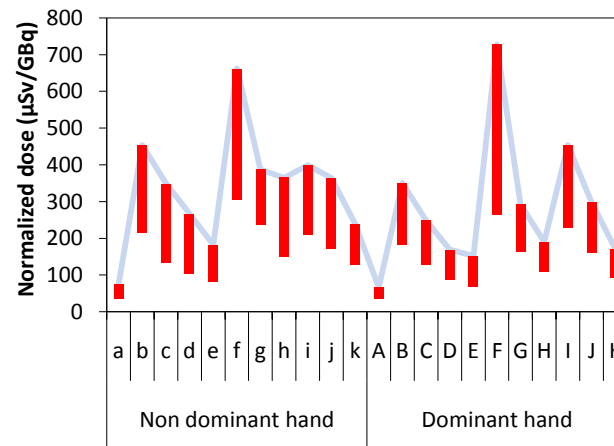
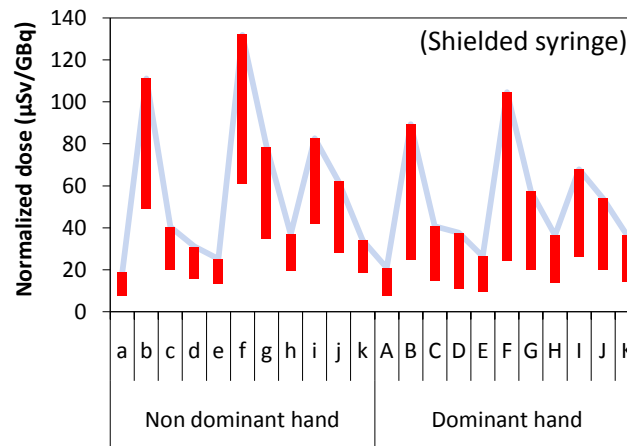
Dose distribution across the hand

Mean and median doses at each measuring position

Preparation

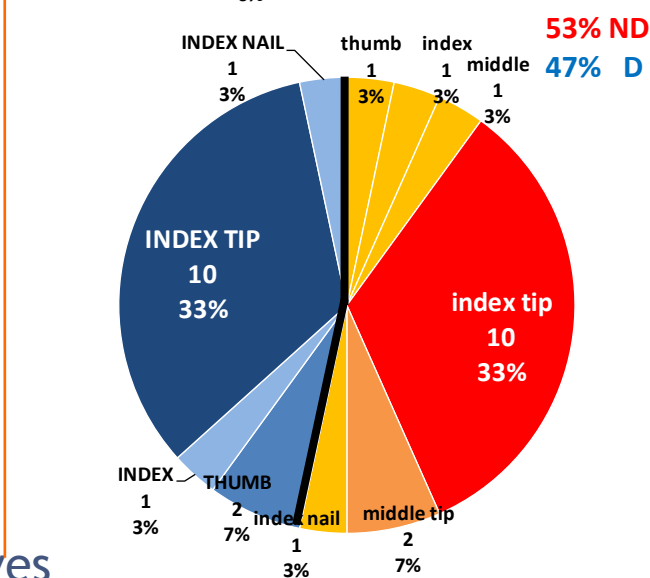
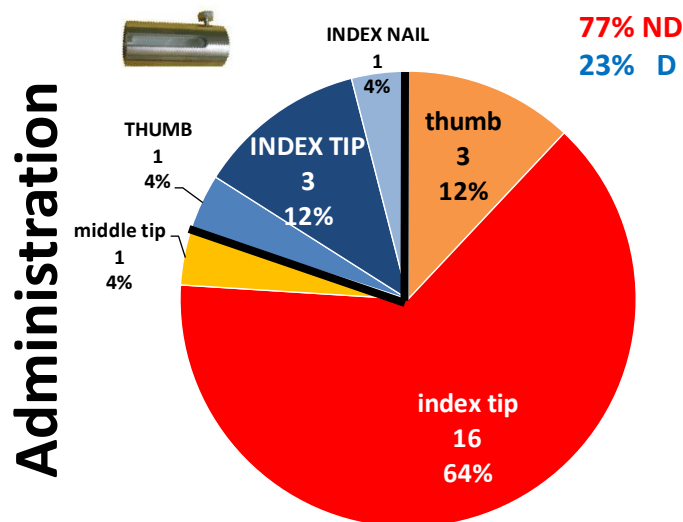
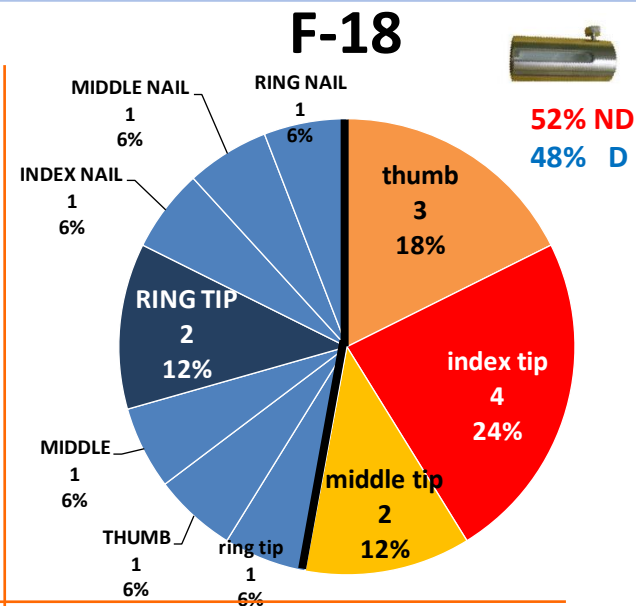
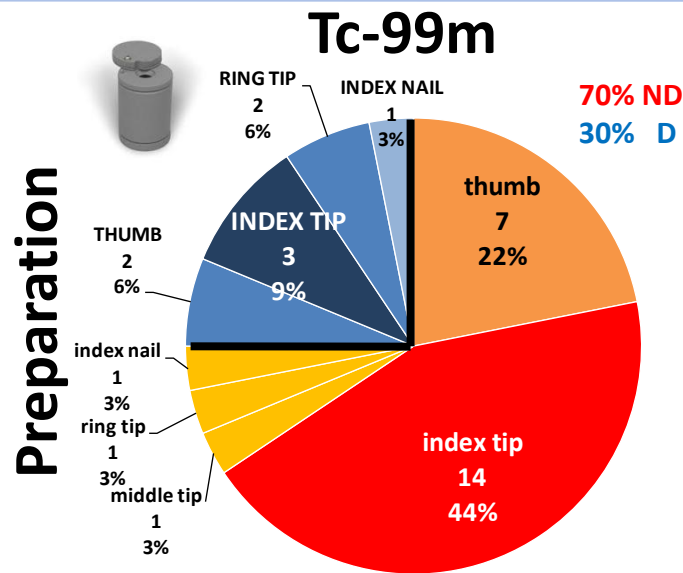


Administration



Similar distributions: index tip and thumb of the ND hand the most exposed. For administration also index tip of the D hand.

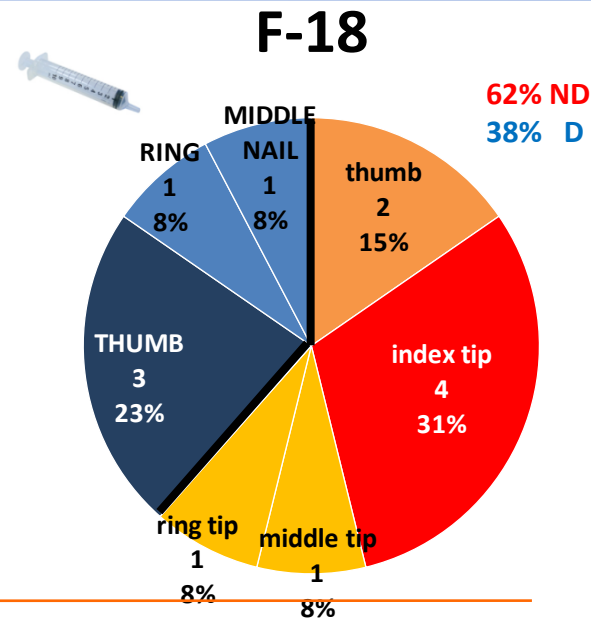
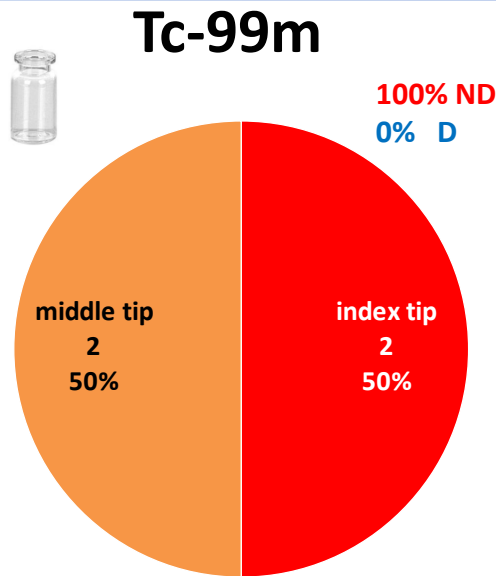
Maximum dose - frequency (with shield)



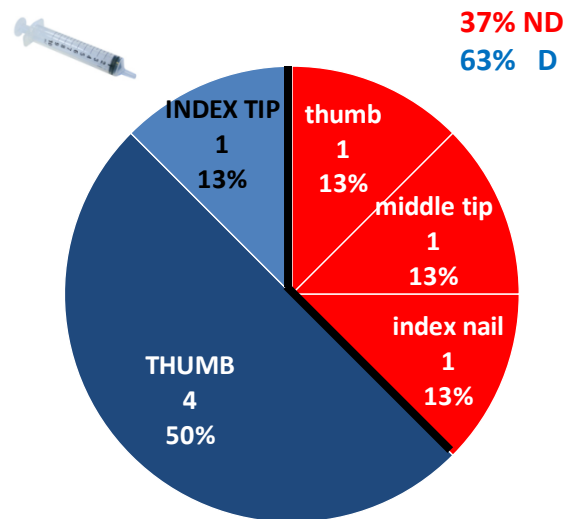
Usually the ND hand receives the highest dose, in particular the index tip.

Maximum dose - frequency (unshielded)

Preparation



Administration

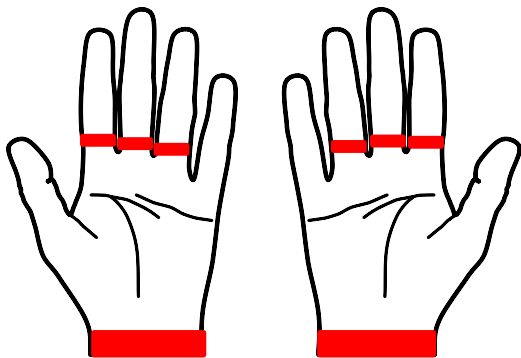


If the vial shield is not used the index and middle tip of the ND hand are always the most exposed (ND hand usually holds the vial). If shield is not used for the syringe the positions with highest dose increase in the D hand, usually the thumb and the index tip.

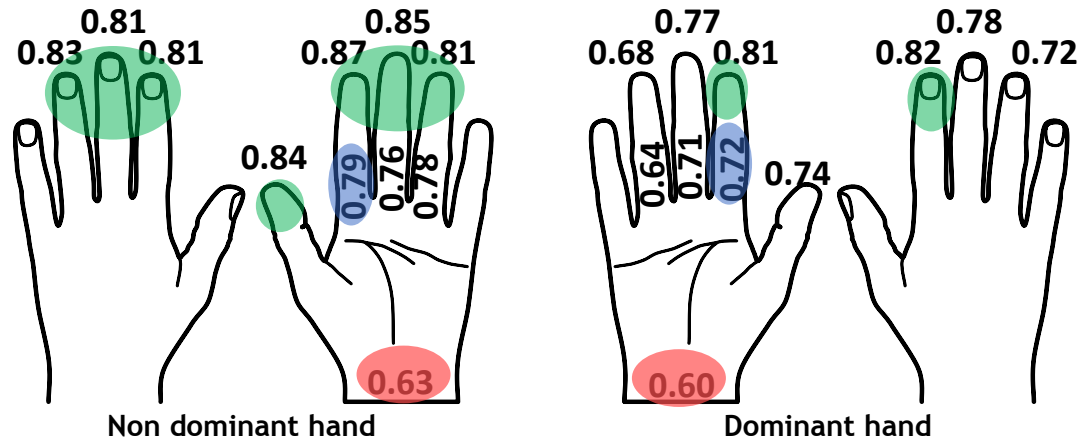
Routine monitoring

- Ideally → measure the maximum dose

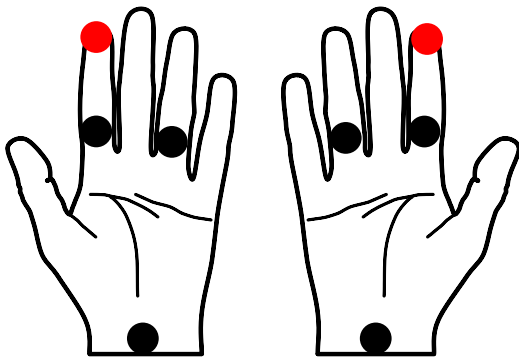
Monitoring positions



Correlations to the maximum dose



(All data)

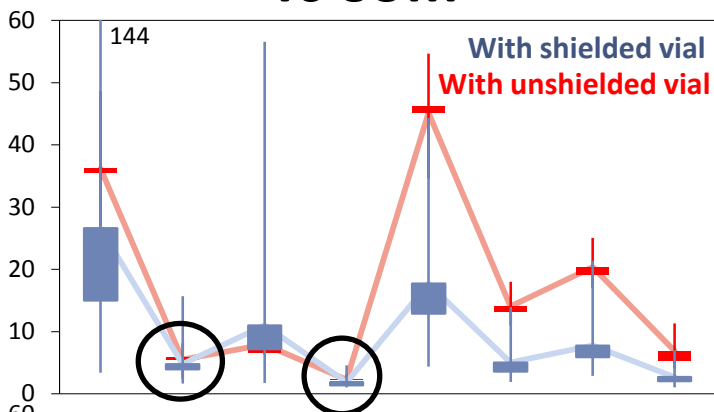


Underestimation of the maximum dose ?
→ Ratios between the maximum dose (considering all measuring positions of both hands) and the dose at the selected positions.

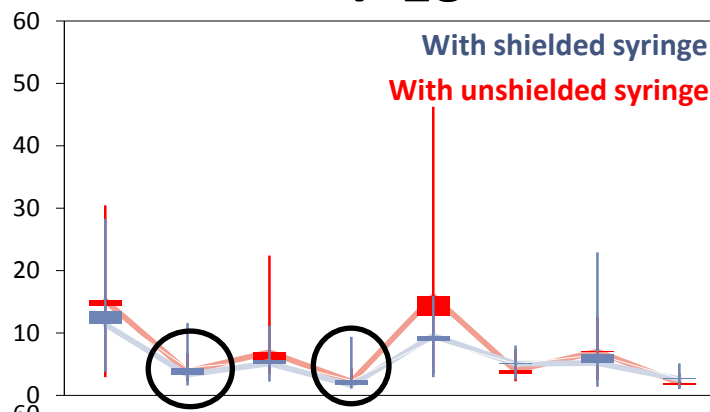
Ratios between the maximum dose and the dose at the monitoring positions (I)

Preparation
Administration

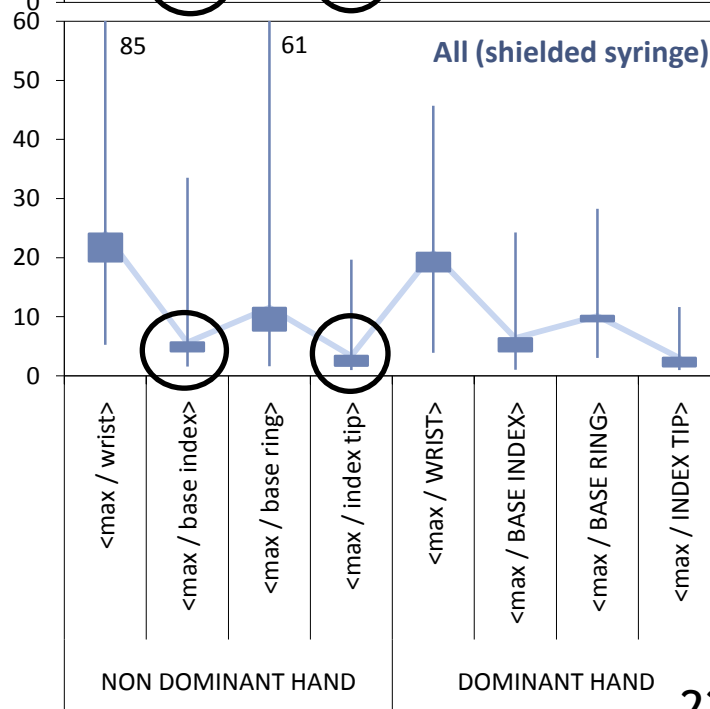
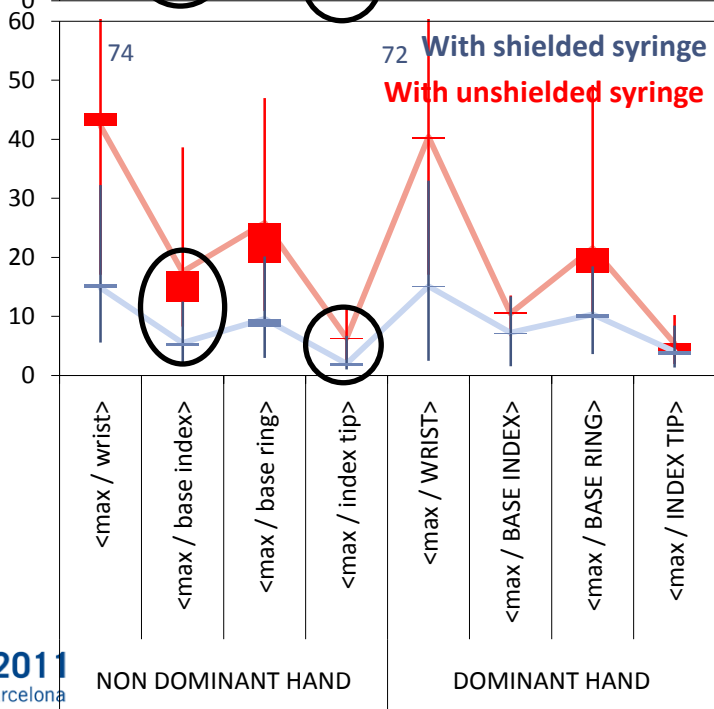
Tc-99m



F-18

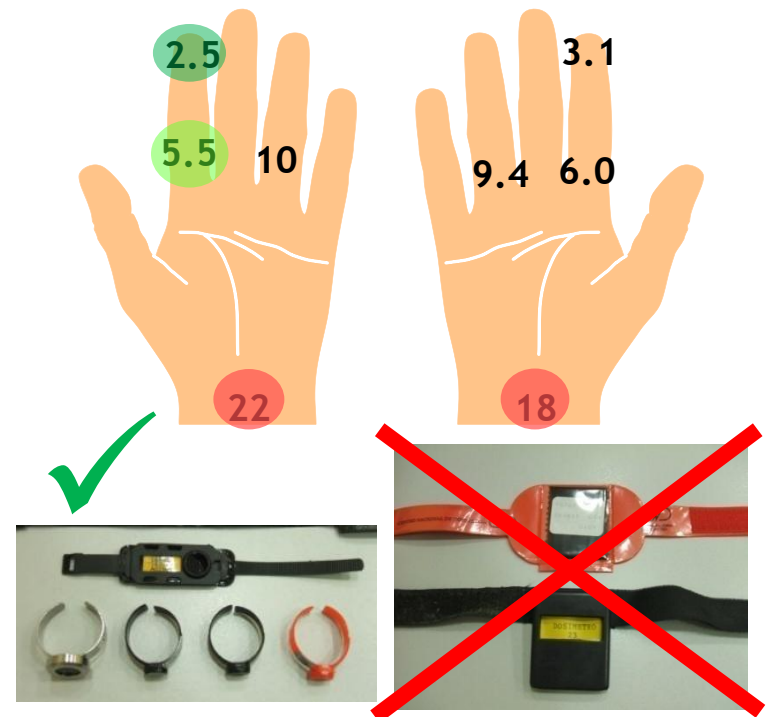
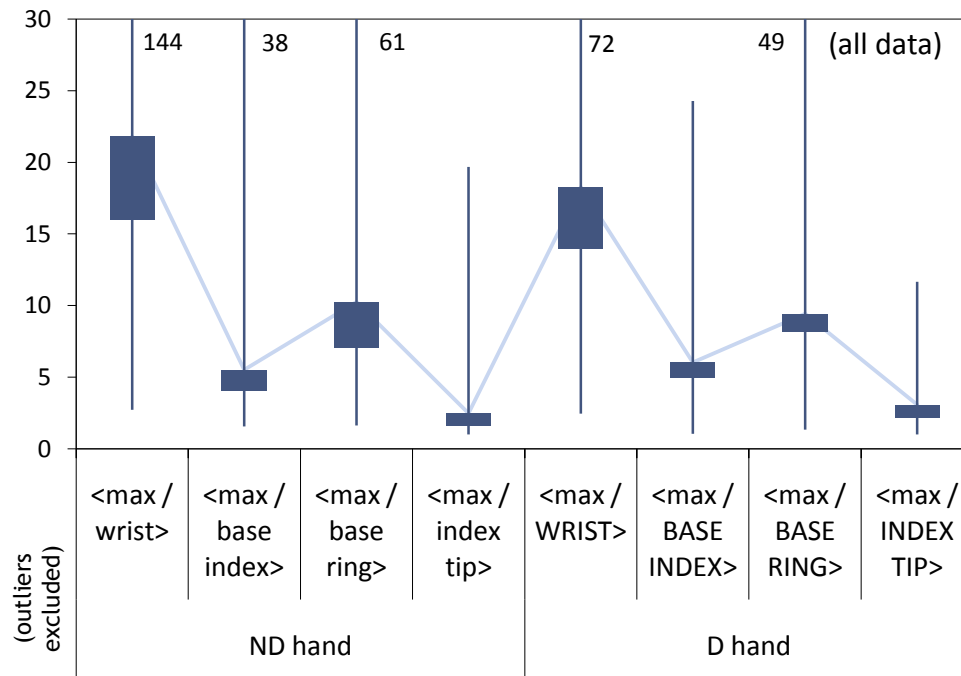


Administration



Ratios between the maximum dose and the dose at the monitoring positions (II)

In a general situation a worker will perform more than one procedure
 → General ratios considering all data independently of the procedure.



- The lowest ratio is for the **index tip** of the **ND hand**, but is not practical.
- The recommended monitoring position is the **base of the index finger** of the **ND hand** (low ratio, high correlation with the maximum) which underestimates the maximum dose by a **factor of 6**.
- We strongly advise against the use of **wrist dosimeters** because of the large underestimation and lowest correlation.

Summary of results and conclusions

- ✓ Large range of finger doses among workers performing the same procedure.
- ✓ In some cases maximum doses can surpass the dose limit.
- ✓ Good and bad practices were identified. For many workers practices can be improved to reduce finger doses. Some guidelines have been proposed (Sans- Merce M. et al. presentation, Saturday 22/01/2011)
- ✓ Shielding was identified to be the most important parameter for dose reduction.
- ✓ The use of wrist dosimeter is not recommended due to the underestimation of the maximum dose by a factor of around 20. It is recommended the use of ring dosimeters placed on the base of the index finger of the non dominant hand, and take into account that it will underestimate the maximum dose by a factor of 6.

Thank you for your attention!