Uncertainties in patient dose estimates. How to design a representative patient dose survey.

Dose Datamed 2

WP4 TRAINING COURSE

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Types of uncertainties

Estimates of the typical effective dose for each type of examination in a country are usually based on measurements of practical dose quantities at a limited number of hospitals or clinics and conversion of these measurements to effective doses

Sources of uncertainty in these estimates include:

1. Uncertainties in the basic dose measurements
2. Uncertainties due to variations in patient doses between hospitals and the limited sample size.
3. Uncertainties in the coefficients used to convert the measured dose quantities into typical effective doses

Uncertainties in basic dosimetry

- Relative uncertainty 7 % at 95 % confidence level (k=2) is required and achievable for patient dose measurements in diagnostic radiology (ICRU Report 74). Careful attention to the calibration procedures and measurement methods is necessary to achieve this level of accuracy.
- In practice uncertainties of about 10-20% are more likely
- These measurement uncertainties are small compared to the variation seen in dose surveys and will not have a significant impact on the accuracy of population dose estimations
- Essentially, the uncertainties due to the variation in measured patient doses between hospitals include the uncertainties in the dose measurements themselves.

Uncertainties due to a limited sample size

- A method has been developed to roughly ascribe uncertainties in the estimated mean value due to the variation in patient doses between x-ray rooms and the limited number of rooms in any survey
- Based on the dose distributions observed in the UK National Patient Dose Database

Uncertainties due to a limited sample size

Random uncertainties in estimated mean doses

Sample size	**SEOM (%)**	**Random uncertainty (95% confidence level)**
> 100 rooms	4.4 (3.3-6.0)*	±10%
20-100 rooms	13 (10-18)*	±25%
5-19 rooms	23 (10-30)*	±50%

* Numbers in brackets indicate range over at least 7 types of x-ray examination (SEOM: standard error of the mean)

Uncertainties due to a limited sample size

- The random uncertainties do not take account of any systematic uncertainty due to potential bias in the sample of rooms chosen that makes them unrepresentative of national practice.
- For small countries where the above sample sizes approach (or even exceed) the total number of radiology rooms in the country, the uncertainties from this source of random error will be much smaller (or even zero).
- If the mean effective dose is taken to be the same as that observed in another country, the uncertainties may be larger by about a factor of 2 (+100%, -50%) (95 % confidence level).

Uncertainties in conversion coeficients

- For many of the common x-ray examinations, conversion coefficients have been calculated with exposure conditions closely matching the average used in clinical practice, so the uncertainties should be small with a 95% confidence limit, probably no more than about ±10%. For other less common examinations the match will not be so good and uncertainties could rise to about ±25%.
- It is consequently very important to use conversion coefficients that were derived under exposure conditions that match clinical practice in a particular country as closely as possible

Overall uncertainties

Sample size and matching of conv. coefficients	Uncertainties at 95 % confidence level		
	Sample size	Conversion coefficient	Overall
>100 rooms Good CC match	± 10 %	± 10 %	± 14 %
20-100 rooms Good CC match	± 25 %	± 10 %	± 27 %
5-19 rooms Good CC match	± 50 %	± 10 %	± 51 %
>100 rooms Poor CC match	± 10 %	± 25 %	± 27 %
20-100 rooms Poor CC match	± 25 %	± 25 %	± 35 %
5-19 rooms Poor CC match	± 50 %	± 25 %	± 56 %
Foreign data only			+100 %, -50 %

Patient dose survey design

- For practical reasons, patient dose surveys are often based on measurements or calculations of practical dose quantities at a limited number of hospitals, practices or clinics (sampling).
- Doses are known to vary widely between hospitals and even between individual radiology rooms or x-ray sets in the same hospital, so the typical national value is usually based on the mean of the radiology room mean dose values for a representative sample of rooms and hospitals in a country
- Because of this wide distribution in mean doses, the design of a patient dose survey, particularly with regard to its size and coverage, is of crucial importance to limit the uncertainty

Patient dose survey design

Attention should be paid to the following points:

- Number of hospitals and clinics included must be large enough to reflect all variations in clinical practice in the country; i.e. variations in the use of equipment, radiographic technique, exposure parameters, contrast agents, etc.
- Number of rooms included from each hospital and the selection of hospitals must be such that they reflect all types of x-ray equipment used for a certain examination type in the country (e.g. covering the age and technology).

Patient dose survey design

Attention should be paid to the following points:

- Sample of patients in each room/facility should be representative regarding their size (weight) and the clinical indication. Ideally doses should be measured or calculated for at least 10 and preferably 20 close-to average size adult patients (e.g. with weights between 60–80 kg)
- Standard examination protocol used should be representative for the average “typical” procedure used in each room/facility for average sized adult patients. Ideally investigate all protocols used in a room/facility to identify the average clinical practice.

Patient dose survey design

Paediatric patients:

- For the purpose of making population dose estimates, it is reasonable to assume that children receive the same mean effective dose as adults
- For this reason, patient dose surveys for population dose can concentrate on adult patients only

http://rileychildrenshospital.com/images/CT_Scan_Child.jpg

Patient dose survey design

Surveys for CT examinations (Example: App 2 of RP 154)

- Information is collected about the typical examination protocols together with measured or displayed values of CTDI and DLP. if these are not available, the CT facility staff can be asked to complete a questionnaire giving details of all the scan parameters used for each type of CT
- Problems:
  - Frequent updates of scanner names and models
  - Variations in CT examination terminology
  - Variations in scanned volume and scan length: diagrams for them should be included
  - Problems to provide complete information

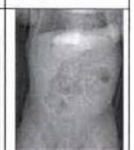
Part 1. Individual Patient Survey: Paediatric **CT examination of abdomen**

Hospital:________________________ **Date:**______________

Clinical indication:____________________________ **Form No.:**____________

Patient data:	**Sex:** (m/f)	**Age:** (year)	**Weight:** (kg)	**Height:** (cm)

Scanner data:	**Manufacturer:**	**Model:**	☐ Single slice ☐ Multi slice, No.:___

Paediatric patient: 0-16 years (actual patient)	Provide data for each axial or helical scan sequence of the examination.			
	Sequence 1	**Sequence 2**	**Sequence 3**	**Sequence 4**
Indicate the actual start and end positions with lines on each image.				
Describe anatomical range scanned				
Standard sequence (routine) or additional in response to initial findings (ad-hoc)	☐ Routine ☐ Ad-hoc	☐ Routine ☐ Ad-hoc	☐ Routine ☐ Ad-hoc	☐ Routine ☐ Ad-hoc
IV contrast used	☐ Y, ☐ N	☐ Y, ☐ N	☐ Y, ☐ N	☐ Y, ☐ N
Nominal beam collimation (mm) Single-slice: e.g. 10 mm Multi-slice: e.g. 4x2.5 mm	____mm __x__mm	____mm __x__mm	____mm __x__mm	____mm __x__mm
Scan field of view (mm or e.g. Head/Body)				
Tube voltage (kV)				
Tube rotation time (s)				
Total tube rotation time for sequence (s)				
Tube current (mA)				
Indicate displayed mAs mAs ☐, mAs/slice ☐, effective mAs ☐.				
Auto dose reduction system used If yes give: name of system and displayed mA ☐ or mAs ☐ used	☐ Y, ☐ N ______ ______	☐ Y, ☐ N ______ ______	☐ Y, ☐ N ______ ______	☐ Y, ☐ N ______ ______
Axial scanning / **Helical scanning**	☐ Axial ☐ Helical	☐ Axial ☐ Helical	☐ Axial ☐ Helical	☐ Axial ☐ Helical
No. of axial slices / Scan length (mm)				
Table incr. (mm) / Pitch				
Table speed/rotation (mm/rotation)				
Image slice reconstruction thickness (mm)				
$CTDI_w$ ☐ or $CTDI_{vol}$ ☐ (indicated) mGy				
DLP for sequence (indicated) mGy·cm				
DLP total examination (indicated) mGy·cm				

Questionnaire for data collection

- Patient age, weight, height
- Area scanned
- Clinical indication
- Applied scan parameters
- Dose indicators provided by the CT scanner


Thank y