# A novel approach for assessing organ doses from paediatric CT scans in **EPI-CT***

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## BACKGROUND

The worldwide increasing use of paediatric computed tomography (CT) has led to increasing concerns regarding the subsequent effects from exposure to ionizing radiation. Availability of accurate estimates of organ-specific doses is essential for quantifying the cancer induction rate per dose unit delivered to the organ. The absorbed organ dose from a CT scan depends on factors such as age, sex, examination type, and time period of scan. This information is available from the hospitals' Radiology Information Systems (RIS) and is used in the ongoing studies. However, individual dosimetry in CT scanning is more complex and a broad variety of technical parameters used to adapt the scanner settings to each specific scan has to be taken into account.


In the *Epidemiological study to quantify risks for paediatric computerized tomography and to optimise doses* (EPI-CT) which brings together the new and already ongoing national studies in nine European countries (Fig. 1), major efforts are undertaken to improve the accuracy of the individual organ dose estimates, and to calculate related uncertainties. In particular, this will be achieved for the more recent time period after introduction of Picture Archiving and Communication System (PACS) databases in the hospitals.

Fig. 1 Estimated size of cohorts by participating countries

## DOSE RECONSTRUCTION

The objective of the EPI-CT dose reconstruction work package is therefore to derive individual organ dose estimates and to account for the variability of dose delivered to exposed organs. For each child in the cohort, organ specific dose estimates will be derived: doses to red bone marrow will be estimated for analyses of leukaemia, doses to other radio sensitive organs (breast, lenses, lung, heart, etc) will also be derived for further analyses which might be conducted later when there will be sufficient statistical power to estimate site specific cancer and non-cancer disease risk.

| STEPS | CHARACTERISTICS OF THE STUDY | COMMENTS |
|---|---|---|
| *Exposure scenarios* | CT scan examinations | Restricted to children |
| *Exposure pathways* | External exposure to X-rays | Predefined CT scan protocols (known sources and exposure conditions) |
| *Methods of estimating doses* | **Individual** organ doses will be estimated from modeling of children using hybrid mathematical phantoms and Monte-Carlo simulations. | Assessment of the characteristics of the medical protocols<br>Collection of individual data from hospital databases (in recent periods) |
| *Uncertainties in dose estimates* | Uncertainties related to missing information on the patients (height and weight) and missing data related to the protocols will be evaluated. | Sensitivity analyses and use of maximum likelihood functions instead of fixed parameters. |
| *Analyses and Results* | Individual organ doses by age and examination types will be provided. | Best estimate will be provided together with distribution of doses. |

## APPROACH

Dosimetric data necessary for dose reconstruction will be obtained in two different ways (Fig. 2) depending on the types of records available in the hospital radiology departments.

For the time period after introduction of PACS, dosimetric data and technical scan parameters will be extracted from Digital Imaging and Communications in Medicine (DICOM) headers using a dedicated software (PerMoS†). Doses will be reconstructed individually from the full protocol recorded in the header. In addition, a new tool has been developed and added to the PerMoS software to allow recognition of scanned body regions (i.e. identification of exposed organs) using segmentation of the images.

For the time period prior to PACS, only limited information about scanner settings and technical parameters used for specific procedures can be obtained from paper files or from RIS databases. A patchwork approach is used to retrieve information from specially developed questionnaires, published surveys, scientific publications, expert interviews and interpolations. Patients will be grouped by time period related to the use of different CT machines, examination types and age and organ doses will be estimated from typical protocols. This approach involves a number of uncertainties but the multisource approach is robust against major errors.

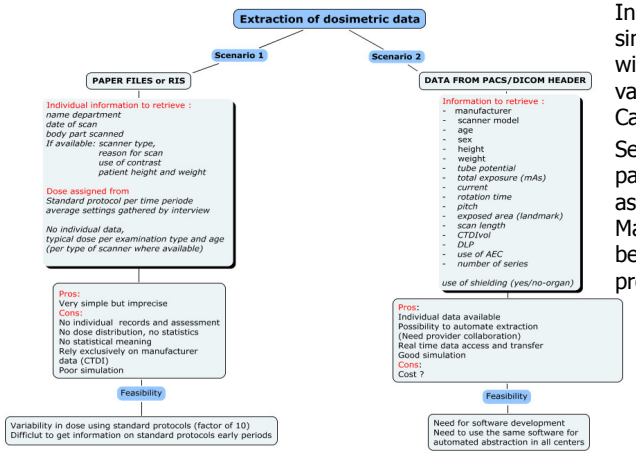


Fig. 2 Scenarios for CT dose reconstruction

In both cases, radiation fields will be simulated together with interactions within the body using phantoms of various ages (Fig. 3) and a Monte-Carlo simulation software‡.

Sensitivity analyses with imputed parameters will be performed to assess the impact of missing values. Maximum likelihood functions will also be derived from available data to provide distributions of doses.

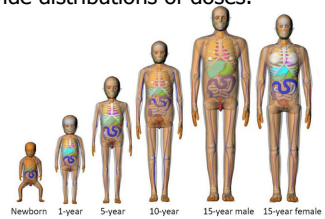


Fig. 3 Family of hybrid phantoms (Courtesy of Dr Choonsik Lee, NCI)

## CONCLUSIONS

Organ doses will be used to evaluate possible risk of leukaemia and other cancers after CT examination early in life. They will also be used to assess technical reasons for variation in dose and image quality. Technical parameters and exposure settings used to produce images for the same CT machine model will be compared to the information available in the radiology departments. In collaboration with paediatric radiologists and manufacturers the best strategies for dose optimization will be defined.

International Agency for Research on Cancer

World Health Organization

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SEVENTH FRAMEWORK PROGRAMME

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