Cumulative radiation doses in medicine: risks for children

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Round Table Discussion on Policy Implications and Research Needs

"Radiosensitivity of children- health issues after radiation exposure at young age"

Arti 31 GoE- Scientific Seminar 2020 - 1st December 2020 (virtual seminar)

Cumulative radiation exposure

Cumulative exposure in multiple scenarios through the life course

Today we will focus on cumulative doses in medicine
(taking the case of paediatric imaging)

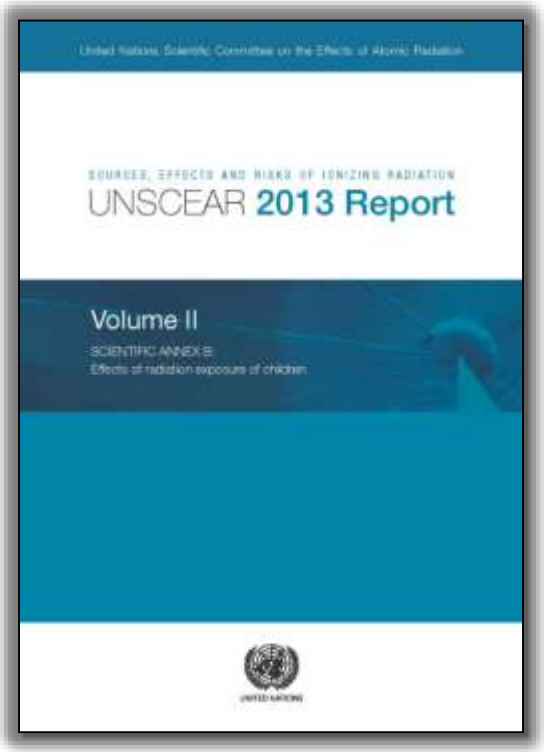
World Health Organization

Cumulative exposure from recurrent imaging procedures

- Recurrent imaging procedures in children may result in significant cumulative doses and associated radiation risks.
  - A balanced approached is required to inform policies and actions, considering **benefits** and **harms** of *performing vs. not performing* the exams.
  - High cumulative doses from recurrent imaging are not necessarily the result of lack of compliance with the fundamental principles of **justification** and **optimization**.

World Health Organization

UNSCEAR 2013 Report: Effects of radiation exposure of children



(b) The Committee has reviewed evolving scientific material and notes that radiogenic tumour incidence in children is more variable than in adults and depends on the tumour type, age and gender. The term "radiation sensitivity" with regard to cancer induction refers to the rate of radiogenic tumour induction. The Committee reviewed 23 different cancer types. Broadly, for about 25 per cent of these cancer types, including leukaemia and thyroid, skin, breast and brain cancer, children were clearly more radiosensitive. For some of these types, depending on the circumstances, the risks can be considerably higher for children than for adults. Some of these cancer types are highly relevant for evaluating the radiological consequences of accidents and of some medical procedures;

https://www.unscear.org/docs/publications/2013/UNSCEAR_2013_Annex-B.pdf

Children are inherently more sensitive to environmental hazards and have a longer life-span to develop long-term health effects like cancer

Cumulative medical exposure should not be confounded with overuse of radiation

- The generic term "**overuse**" refers to any services that are unnecessary in any way and for any reason.
  - *Recurrent imaging procedures may be indicated for particular clinical conditions: the process of justification applies to each procedure, in the context of the entire health care pathway, to ensure that they will cause **more good than harm**.*
  - *In addition of assessing the incremental dose and associated risk for each individual procedure, an integrated approach may be warranted to consider **cumulative dose** and **lifetime attributable risk** (**LAR**) taking into account gender, age at exposure and attained age.*

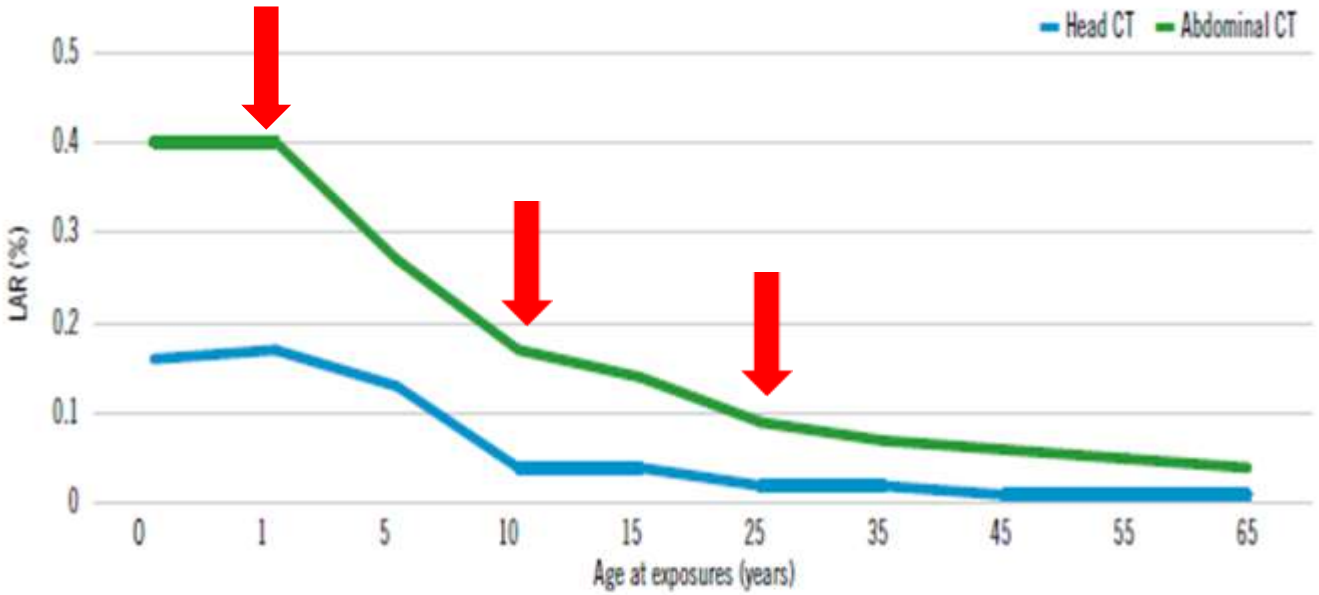
World Health Organization

We may use typical radiation doses in paediatric procedures for comparative purposes

Diagnostic procedure	Equivalent number of chest X-rays	Equivalent period of exposure to natural radiation[b]	Typical effective dose (mSv)
Chest X-ray (single PA film)			
Adult	1	3 days	0.02[c]
5-year-old	1	3 days	0.02[c]
CT head			
Adult	100	10 months	2[c]
Newborne	200	2.5 years	6
1-year-old	185	1.5 years	3.7
5-year-old	100	10 months	2[d]
10-year-old	110	11 months	2.2
Paediatric head CT angiography[f]	250	2 years	5
CT chest			
Adult	350	3 years	7[c]
Newborng	85	8.6 months	1.7
1-year-old	90	9 months	1.8
5-year-old	150	1.2 years	3[d]
10-year-old	175	1.4 years	3.5

However, when referring to radiation risks associated with medical exposures, the organ dose (rather than the effective dose) is the appropriate quantity to consider.

Figure 9: Sex-averaged lifetime attributable risk of cancer incidence associated with radiation exposure during head and abdominal CT, as a function of the age at exposure



- **LAR** for cancer incidence associated with head CT and abdominal CT performed at different ages, based on typical **organ dose** estimates for 16 different organs. Assuming the **LNT model**, and keeping in mind the **uncertainty on risk estimates from low-dose radiation exposure**, the practical value of this figure would be for comparing risks from different examinations with regard to the age at exposure.

https://www.who.int/ionizing_radiation/pub_meet/radiation-risks-paediatric-imaging/en/

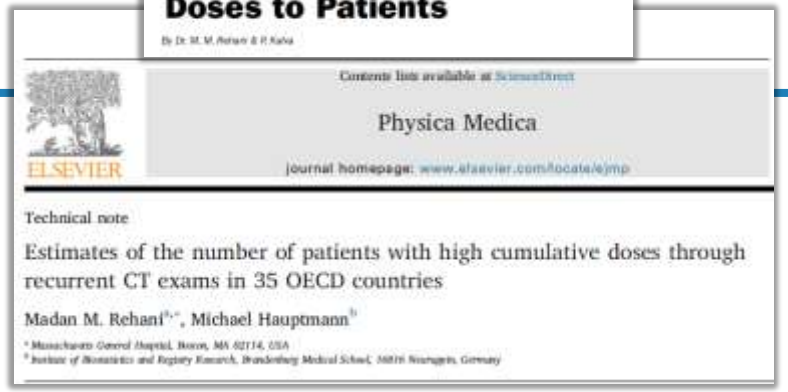
World Health Organization

Cumulative exposure

- The lifetime attributable risk (**LAR**) should be put in the context of the high lifetime baseline risk (**LBR**) for cancer incidence, and the benefits provided by a CT scan if it is medically necessary.
- Nevertheless, the public health issue at hand concerns the increasingly **large paediatric population** being exposed and the **cumulative** exposure / risks to **individual patients**.


RADIATION EXPOSURE

High Cumulative Radiation Doses to Patients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Technical note

Estimates of the number of patients with high cumulative doses through recurrent CT exams in 35 OECD countries

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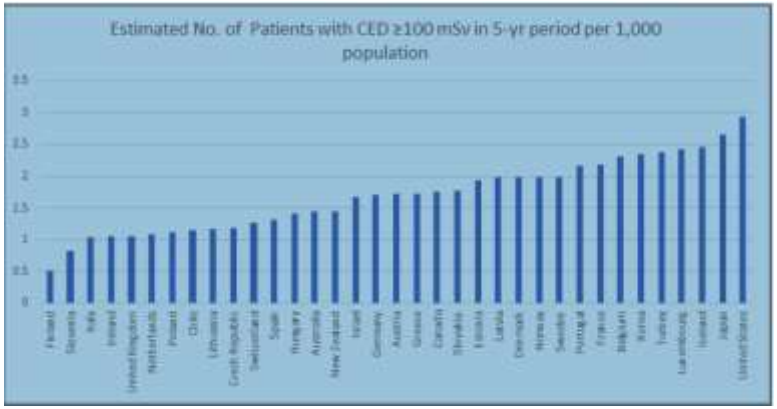
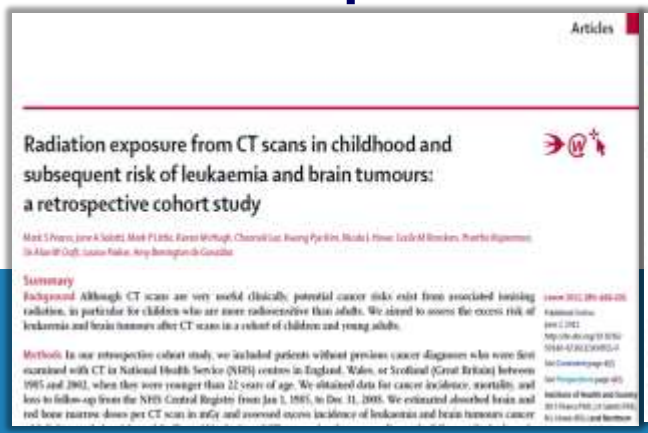
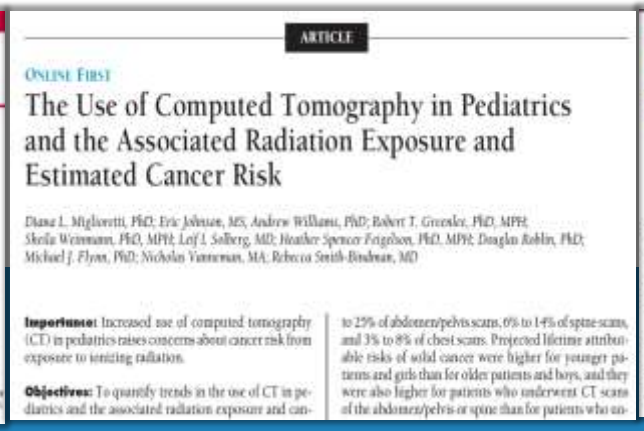



Articles

Radiation exposure from CT scans in childhood and subsequent risk of leukaemia and brain tumours: a retrospective cohort study

Summary


ARTICLE

ONLINE FIRST

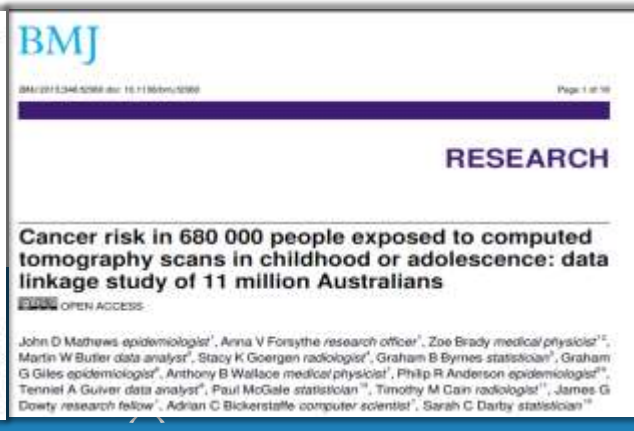
The Use of Computed Tomography in Pediatrics and the Associated Radiation Exposure and Estimated Cancer Risk

Diana L. Miglioretti, PhD; Eric Johnson, MS; Andrew Williams, PhD; Robert T. Greenlee, PhD, MPH; Sheila Weinmann, PhD, MPH; Leif I. Solberg, MD; Heather Spencer Feigelson, PhD, MPH; Douglas Roblin, PhD; Michael J. Flynn, PhD; Nicholas Vanneman, MA; Rebecca Smith-Bindman, MD

Importance: Increased use of computed tomography (CT) in pediatrics raises concerns about cancer risk from exposure to ionizing radiation.

Objectives: To quantify trends in the use of CT in pediatrics and the associated radiation exposure and can-

to 25% of abdomen/pelvis scans, 6% to 14% of spine scans, and 3% to 8% of chest scans. Projected lifetime attributable risks of solid cancer were higher for younger patients and girls than for older patients and boys, and they were also higher for patients who underwent CT scans of the abdomen/pelvis or spine than for patients who un-


BMJ

RESEARCH

Cancer risk in 680 000 people exposed to computed tomography scans in childhood or adolescence: data linkage study of 11 million Australians

OPEN ACCESS

John D Mathews *epidemiologist*[1], Anna V Forsythe *research officer*[1], Zoe Brady *medical physicist*[1,2], Martin W Butler *data analyst*[3], Stacy K Goergen *radiologist*[4], Graham B Byrnes *statistician*[5], Graham G Giles *epidemiologist*[6], Anthony B Wallace *medical physicist*[7], Philip R Anderson *epidemiologist*[8], Tenniel A Guiver *data analyst*[6], Paul McGale *statistician*[10], Timothy M Cain *radiologist*[11], James G Dowty *research fellow*[1], Adrian C Bickerstaffe *computer scientist*[1], Sarah C Darby *statistician*[10]

Policy actions to enhance:

- **JUSTIFICATION**: Help counter overly optimistic expectations about recurrent imaging and inform decision making and consent if recurrent imaging is indicated (evidence-based guidelines anticipating conditions where recurrent procedures are likely, evidence-informed + individually-tailored decision making, NIR modalities as alternative or first choice.
- **OPTIMIZATION**: ensure radiation dose management for every single exam when recurrent imaging is indicated for diagnosis, image-guided interventions and/or follow-up (technological solutions, customized protocols & working procedures, DRLs)
- **SAFETY CULTURE** instilled in prospectively identified care pathways that may need recurrent imaging in children,

Advocacy, education and training

- Medical profession's general underlying beliefs may drive unnecessary **recurrent imaging**:
  - Long embraced feelings that in medicine "*more is better*";
  - Not easy to accept the inevitability of uncertainty.
  - Medical education focused on how to reach definite diagnoses and take actions to treat diseases;
  - Not much discussion about when it may be better not to be active making the "*watchful waiting*" approach often uncomfortable for both doctors and patients/ parents (even if it may be appropriate);

Need for repositioning advocacy, education and training for both professionals and the wider community

Some research gaps and needs

- Continued research is needed to identify the full scope and expression of the differences in effects, mechanisms and risk from IR exposure for children and for adults (UNSCEAR, 2013):
  - Long-term epi studies for medical exposure in childhood (e.g. CT, interventional fluoroscopy, radiotherapy), organ dose data bases, dose distribution data, interaction with other exposures/ therapies,

- Biological mechanisms relevant for assessing low-dose radiation risks of exposure during childhood such as:
  - DNA damage & repair, epigenetic effects, genomic instability, individual radiosensitivity; persistence of change, clinical relevance and actual health effects across lifetime (e.g. carcinogenesis, immune system, others);influence of the age, sex, dose/dose rate, radiation quality, acute vs. fractionated/ protracted exposure.