Evaluating and communicating risks and benefits in pediatric imaging

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Vienna, Austria, 18th September 2017
World Health Organization: function
UN directing and coordinating authority on international health work

- Objective: attainment by all peoples of the highest possible level of health

"Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity."

(WHO Constitution, 1948)
World Health Organization: structure

Ministries of Health
194 Member States

Headquarters
Geneva

6 Regional Offices

150 Country Offices

IARC, Lyon

Geneva

IARC, Lyon

World Health Organization
Towards achieving the Sustainable Development Goals (SDGs)

All UN Member States agreed to try to achieve the 17 SDGs by 2030

WHO welcomes the IAEA initiative of organizing this joint side event, which is consistent with the aspiration “Together for a healthier world”
Medical imaging is an essential component of modern health care. The clinical value of radiological imaging procedures for the diagnosis of illness and injury is widely recognized.

The benefits for patients far outweigh the radiation risks when exams using radiation are appropriately prescribed and properly performed. This is particularly critical in pediatric imaging.

**JUSTIFICATION**

**OPTIMIZATION**
The major challenge in RP in health care

The wide use of radiation in medicine calls for a **public health** approach to control and minimize health **risks**, while maximizing the **benefits**.
Which are the radiation risks?

- Beyond certain dose thresholds, radiation can impair the functioning of tissues and/or organs and can produce acute effects such as skin redness, hair loss, radiation burns, or acute radiation syndrome.

- These 'tissue reactions' are more severe at higher doses and higher dose rates.
Radiation risks at low doses

- If the dose is low or delivered over a long period of time (low dose rate), there is greater likelihood for successfully repair the cell damage. If this damage is repaired with errors, this transformation may lead to cancer after years or even decades have passed (so-called 'stochastic effects').
Risks from prenatal exposures to ionizing radiation (IR)

- Risks depend on the radiation dose and the period of the pregnancy when the exposures occur.
- Prenatal exposure to IR may induce fetal brain damage following an acute dose exceeding 100 mSv between weeks 8-15 of pregnancy and 200 mSv between weeks 16-25 of pregnancy (mental retardation, IQ decrease). Before week 8 or after week 25 of pregnancy human studies have not shown radiation effects on the fetal brain.
- Epidemiological data showed statistical association between prenatal exposure to IR and childhood cancer, particularly leukaemia.
Children & environmental threats

- Children are inherently more sensitive to environmental hazards:
  - physical, physiological, cognitive immaturity;
  - > proportion of proliferating cells;

- Prenatal life has periods of exquisite sensitivity to the effects of toxic agents
  - Prenatal exposures can affect developmental processes;

- Children have a longer life-span to develop long-term health effects like cancer

**Kids Are Not Little Adults**
Radiation exposure from CT scans in childhood and subsequent risk of leukaemia and brain tumours: a retrospective cohort study

Mark S Pearce, Jane A Salotti, Mark P Little, Kieran McHugh, Choonsik Lee, Kwang Pyo Kim, Nicola L Howe, Cecile M Ronckers, Preetha Rajaraman, Sir Alan W Craft, Louise Parker, Amy Berrington de González

Summary
Background Although CT scans are very useful clinically, potential cancer risks exist from associated ionising radiation, in particular for children who are more radiosensitive than adults. We aimed to assess the excess risk of leukaemia and brain tumours after CT scans in a cohort of children and young adults.

Methods In our retrospective cohort study, we included patients without previous cancer diagnoses who were first examined with CT in National Health Service (NHS) centres in England, Wales, or Scotland (Great Britain) between 1985 and 2002, when they were younger than 22 years of age. We obtained data for cancer incidence, mortality, and loss to follow-up from the NHS Central Registry from Jan 1, 1985, to Dec 31, 2008. We estimated absorbed brain and red bone marrow doses per CT scan in mGy and assessed excess incidence of leukaemia and brain tumours cancer
Cancer risk in 680 000 people exposed to computed tomography scans in childhood or adolescence: data linkage study of 11 million Australians

John D Mathews epidemiologist¹, Anna V Forsythe research officer¹, Zoe Brady medical physicist¹², Martin W Butler data analyst³, Stacy K Goergen radiologist⁴, Graham B Byrnes statistician⁵, Graham G Giles epidemiologist⁶, Anthony B Wallace medical physicist⁷, Philip R Anderson epidemiologist⁸⁹, Tenniel A Guiver data analyst⁸, Paul McGale statistician¹⁰, Timothy M Cain radiologist¹¹, James G Dowty research fellow¹, Adrian C Bickerstaffe computer scientist¹, Sarah C Darby statistician¹⁰
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 cancer risk: 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-
Ongoing epidemiological study EPI-CT

To investigate the relationship between the exposure to ionizing radiation from CT scans in childhood and adolescence and possibly attributable late health effects. 18 centres from Belgium, Denmark, Germany, Finland, France, Luxembourg, the Netherlands, Norway, Spain, Sweden and the United Kingdom collaborate to enrol approximately one million patients.
(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;
How to reduce unnecessary radiation exposure in children?

- **Justification** of every radiological procedure performed in pediatric health care is the first step to reduce unnecessary radiation exposure in children.

- Imaging techniques that do not use ionizing radiation should be considered as a possible alternative.

- If the procedure is justified, the risk to the kid of not undergoing the examination is greater than the potential risks of the radiation exposure associated with the practice.

- Once the procedure was justified, it has to be performed ensuring optimization of protection and safety.
Some actions to reduce unnecessary radiation exposures in children

- Raise awareness about radiation doses and risks in children.
- Educate on dose reduction strategies without compromising the diagnostic quality of the images.
- Review/ adapt protocols according to the child’s size and the clinical question/s to be answered, establish DRLs.
- Establish and maintain a radiation safety culture engaging the radiology team (radiologist, technologists, medical physicist) together with referring physicians, patients/parents and other stakeholders, to improve quality and safety in pediatric imaging.
Health-care providers requesting or performing radiological imaging procedures in children share the responsibility to communicate radiation risks accurately and effectively to patients, parents and other caregivers.

They need information and resources about pediatric imaging, to ensure a balanced benefit-risk dialogue to support informed decision making in pediatric imaging.
Radiation risk communication tools for health care providers to support risk-benefit dialogue.

Primarily targeted to health-care providers who refer children to perform imaging procedures involving radiation exposure (also useful for other stakeholders).
A toolkit to communicate radiation risks
Document in English

Executive Summary in 7 languages

Contents & structure

Chapter 1: Scientific background

Chapter 2: Radiation protection concepts and principles

Chapter 3: Risk-benefit dialogue
Types of radiation, quantities & units

Box 1.1 Quantities and units

The absorbed dose is the amount of energy deposited in tissues/organisms per unit of mass and its unit is the gray (Gy). One gray is a very large unit for diagnostic imaging and it is often more practical to talk in terms of milligrays (mGy). One gray is equal to one thousand milligrays.

Box 1.2 How to express an amount of radioactive material

The becquerel (Bq) is the unit of radioactivity used in the International System of Units. In nuclear medicine it is used to express the amount of radioactivity administered to a patient. It is a quite large amount of radioactive material: it corresponds to $3.7 \times 10^9$ (37 billion) radioactive disintegrations per second. Today, the unit Ci is hardly ever used worldwide but it is still in use.

<table>
<thead>
<tr>
<th>Food</th>
<th>$^{40}$K (Potassium)</th>
<th>$^{226}$Ra (Radium)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banana</td>
<td>130 Bq/kg</td>
<td>0.037 Bq/kg</td>
</tr>
<tr>
<td>Brazil Nuts</td>
<td>207 Bq/kg</td>
<td>37–260 Bq/kg</td>
</tr>
<tr>
<td>Carrot</td>
<td>130 Bq/kg</td>
<td>0.02–0.1 Bq/kg</td>
</tr>
<tr>
<td>White Potato</td>
<td>130 Bq/kg</td>
<td>0.037–0.09 Bq/kg</td>
</tr>
<tr>
<td>Beer</td>
<td>15 Bq/kg</td>
<td>NA</td>
</tr>
<tr>
<td>Red Meat</td>
<td>110 Bq/kg</td>
<td>0.02 Bq/kg</td>
</tr>
</tbody>
</table>
Sources of radiation exposure

Figure 1: Distribution of average annual radiation exposure for the world population

Worldwide average radiation exposure (mSv)
Total: 3 mSv

- Artificial sources other than medical (0.3%) — 0.01
- Radon (41.7%) — 1.26
- Natural sources other than radon (38.3%) — 1.14
- Medical exposure (19.7%) — 0.6

Figure 2: Average annual radiation exposure for the USA population presented in the same way as Fig. 1 for comparison purposes

US average radiation exposure (mSv)
Total: 6.11 mSv

- Artificial sources other than medical (0.3%) — 0.15
- Radon (33%) — 1.98
- Natural sources other than radon (16%) — 0.98
- Medical exposure (~50%) — 3.0

Source: Adapted, with permission, from UNSCEAR (2010)

Source: Adapted, with permission, from NCRP (2009)
Chapter 1: Scientific background

Section 1.1

Sources of radiation exposure, current trends in the use of ionizing radiation in medical imaging

Figure 4 Variation in the contribution of medical exposure to the annual average radiation dose per person in countries with similar health care level

United States (2006)

Germany (2005)

United Kingdom (2005)

Source: Adapted, with permission, from UNSCEAR (2010)
Chapter 1: Scientific background

Section 1.1 (cont’)

Figure 3: Annual average radiation dose per person (mSv) in the USA population: note the rise in exposure due to medical imaging over the years.

Figure 5: Percentage of the total CT scans which are performed in children in different regions of the world.
## Table 2. Global average relative frequency and collective dose of various types of diagnostic X-ray procedures (all ages, both sexes)\(^a\)

<table>
<thead>
<tr>
<th>X-ray examination</th>
<th>Relative frequency (%)</th>
<th>Collective dose (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest examinations (PA, lateral, others)</td>
<td>40</td>
<td>13.3</td>
</tr>
<tr>
<td>Limb and joint</td>
<td>8.4</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>Skull</td>
<td>3.2</td>
<td>4.2</td>
</tr>
<tr>
<td>Abdomen, pelvis, hip</td>
<td>5.2</td>
<td>4.5</td>
</tr>
<tr>
<td>Spine</td>
<td>7.4</td>
<td>4.2</td>
</tr>
<tr>
<td>Fluoroscopic studies of the gastrointestinal tract</td>
<td>4.8</td>
<td>14.5</td>
</tr>
<tr>
<td>Mammography</td>
<td>3.6</td>
<td>&lt; 1</td>
</tr>
<tr>
<td><strong>Computed tomography</strong></td>
<td><strong>6.3(^b)</strong></td>
<td><strong>43.2(^b)</strong></td>
</tr>
<tr>
<td>Angiography and fluoroscopy-guided interventional procedures</td>
<td>&lt; 1</td>
<td>6.1</td>
</tr>
<tr>
<td>Other X-ray medical imaging procedures</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>Dental procedures(^c)</td>
<td>13</td>
<td>&lt; 1</td>
</tr>
</tbody>
</table>
### Section 1.2

Typical radiation doses in paediatric procedures

<table>
<thead>
<tr>
<th>Diagnostic procedure</th>
<th>Equivalent number of chest X-rays</th>
<th>Equivalent period of exposure to natural radiation</th>
<th>Typical effective dose (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chest X-ray (single PA film)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult</td>
<td>1</td>
<td>3 days</td>
<td>0.02(^c)</td>
</tr>
<tr>
<td>5-year-old</td>
<td>1</td>
<td>3 days</td>
<td>0.02(^c)</td>
</tr>
<tr>
<td><strong>CT head</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult</td>
<td>100</td>
<td>10 months</td>
<td>2(^c)</td>
</tr>
<tr>
<td>Newborn</td>
<td>200</td>
<td>2.5 years</td>
<td>6</td>
</tr>
<tr>
<td>1-year-old</td>
<td>185</td>
<td>1.5 years</td>
<td>3.7</td>
</tr>
<tr>
<td>5-year-old</td>
<td>100</td>
<td>10 months</td>
<td>2(^d)</td>
</tr>
<tr>
<td>10-year-old</td>
<td>110</td>
<td>11 months</td>
<td>2.2</td>
</tr>
<tr>
<td>Paediatric head CT angiography(^i)</td>
<td>250</td>
<td>2 years</td>
<td>5</td>
</tr>
<tr>
<td><strong>CT chest</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult</td>
<td>350</td>
<td>3 years</td>
<td>7(^c)</td>
</tr>
<tr>
<td>Newborn</td>
<td>85</td>
<td>8.6 months</td>
<td>1.7</td>
</tr>
<tr>
<td>1-year-old</td>
<td>90</td>
<td>9 months</td>
<td>1.8</td>
</tr>
<tr>
<td>5-year-old</td>
<td>150</td>
<td>1.2 years</td>
<td>3(^d)</td>
</tr>
<tr>
<td>10-year-old</td>
<td>175</td>
<td>1.4 years</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Table 4. Typical effective doses for diagnostic imaging examinations and their equivalence in terms of number of chest X-rays and duration of exposure to natural background radiation\(^a\)
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.
Basic concepts & principles of radiation protection and how they are applied to pediatric imaging.

When considering the use of radiation in pediatric imaging a benefit/risk balance analysis must be carefully considered.

The use of radiation will be unnecessary if clinical evaluation or other imaging modalities (e.g. US, MRI) could provide an accurate diagnosis.

Do the right procedure!
Do the procedure right!
The benefit outweighs the risk when the procedure is:

- appropriately prescribed
- properly performed

This is not the case if there is no clinical indication or if the radiation dose is higher than necessary for the clinical purpose (e.g. if adult protocols are used for imaging children)

*e.g. the Image gently messages:*

“When imaging kids, image gently!”
“One size does not fit all!”
“Be wise, adjust for size”
### Section 2.1

**Table 9.** Socratic questions for referring clinicians when considering imaging procedures

<table>
<thead>
<tr>
<th>What the referrer should answer</th>
<th>Preventable, wasteful medical exposures to radiation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Has it been done already?</td>
<td>Unnecessarily repeating investigations that have been already done</td>
</tr>
<tr>
<td>Do I need it?</td>
<td>Undertaking investigations when results are unlikely to affect patient management</td>
</tr>
<tr>
<td>Do I need it now?</td>
<td>Investigating too early</td>
</tr>
<tr>
<td>Is this the best investigation?</td>
<td>Doing the wrong investigation</td>
</tr>
<tr>
<td>Have I explained the problem?</td>
<td>Failing to provide appropriate clinical information and questions that the imaging investigation should answer</td>
</tr>
</tbody>
</table>

* Classical method to stimulate erudite thought, which has been used in radiology education (Zou et al., 2011)

Source: Adapted from RCR (2012), with kind permission of The Royal College of Radiologists.
Section 2.1

**JUSTIFICATION:** Imaging referral guidelines are tools to improve appropriateness of paediatric imaging referrals.
Section 2.1

**OPTIMIZATION**: diagnostic reference levels (DRLs) are tools to improve optimization of protection in pediatric imaging.

### Table 10. Examples of the influence of some common adjustable CT techniques on patient radiation dose

<table>
<thead>
<tr>
<th>CT Technique</th>
<th>Influence on Radiation Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>X-ray energy (kilovoltage peak - kVp)*</td>
<td>Decreased kVp → decreased dose</td>
</tr>
<tr>
<td>Tube current (milliamperes - mA)*</td>
<td>Decreased mA → decreased dose</td>
</tr>
<tr>
<td>X-ray tube rotation speed (seconds)*</td>
<td>Faster tube (gantry) spinning → decreased dose</td>
</tr>
<tr>
<td>Scanning range/distance (in cm)</td>
<td>Shorter scanning distance → decreased dose</td>
</tr>
<tr>
<td>Patient position in scanner</td>
<td>Improper positioning in gantry can increase dose</td>
</tr>
<tr>
<td>Number of scan sequences (phases)</td>
<td>Increasing phases (e.g. pre and post contrast) increases dose</td>
</tr>
<tr>
<td>Scanning multiple body regions</td>
<td>Minimizing scan overlap decreases dose</td>
</tr>
<tr>
<td>Optimal use of intravenous contrast (dye)</td>
<td>Improved structure visibility may afford lower settings (e.g. kVp)</td>
</tr>
<tr>
<td>Special technologies</td>
<td>Scanner dependent; additional dose reduction capabilities</td>
</tr>
</tbody>
</table>
Establish and maintain a radiation safety culture in health care.

Box 2.4 Steps to establish and maintain radiation safety culture

(a) Promote individual and collective commitment to protection and safety at all levels of the organization
(b) Ensure a common understanding of the key aspects of safety culture within the organization
(c) Provide the means by which the organization supports individuals and teams in carrying out their tasks safely and successfully, with account taken of the interactions between individuals, technology and the organization
(d) Encourage the participation of workers and their representatives and other relevant persons in the development and implementation of policies, rules and procedures dealing with protection and safety
(e) Ensure accountability of the organization and of individuals at all levels for protection and safety
(f) Encourage open communication with regard to protection and safety within the organization and with relevant parties, as appropriate
(g) Encourage a questioning and learning attitude and discourage complacency with regard to protection and safety
(h) Provide the means by which the organization continually seeks to develop and strengthen its safety culture.

Source: Adapted from BSS (2014), with permission from IAEA
Section 3.1

Practical tips to support the risk-benefit dialogue

Natural, reversible, well understood, clear benefit, voluntary, controllable, certain, familiar, immediate effects, not affecting: children, pregnant women and/or future generations

Human-made, irreversible, poorly understood, unclear benefit, imposed, uncontrollable, uncertain, unfamiliar, delayed effects, affecting: children, pregnant women, future generations
### Table 12. Clinical questions about risks of a radiological examination and possible answers

<table>
<thead>
<tr>
<th>Question</th>
<th>Possible responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Why are you recommending this radiological examination?”</td>
<td>“We need more information to clarify your child’s diagnosis, and to direct our treatment. This radiological examination can rapidly and accurately provide that information.”</td>
</tr>
<tr>
<td>“Are there any risks of this radiological examination?”</td>
<td>“One concern is the possibility of cancer resulting from the radiation from this examination.”</td>
</tr>
<tr>
<td>“How great is this risk?”</td>
<td>“The risk from this radiological examination is very small, if a risk at all. We are not certain that there is a risk at very low doses, like those doses in the vast majority of X-ray procedures or CT.”</td>
</tr>
</tbody>
</table>
| “How does the risk from this radiological examination compare to the risk of [my child’s presenting condition]?” | “I have considered your current situation carefully, taking into account many factors.” Depending on the circumstances:  
  - “I have significant concern that your child has an injury or serious medical condition. The risk of this radiological examination is at most very small by comparison, so this radiological examination is the right test to perform.”  
  - “At the present time, your child appears to have minimal risk of a serious medical condition.” |
c) What medical imaging procedures use ionizing radiation?

- The most common radiological imaging procedures utilizing ionizing radiation are: conventional radiography, computed tomography (CT), fluoroscopy, and nuclear medicine examinations, including positron emission tomography (PET) and single-photon emission computed tomography (SPECT), as well as hybrid techniques combining these modalities (e.g. PET-CT).

d) What medical imaging procedures do not use ionizing radiation?

- Two common imaging techniques that do not utilize ionizing radiation are ultrasound and magnetic resonance imaging (MRI).

e) Why can't we do a procedure that does not use radiation instead?

- Your child's physician (e.g., paediatrician, family physicians) can talk with the imaging specialist to get help in determining which type of test might be best.
- We have considered using examinations that do not require radiation, but we have determined that they will not give us the necessary information.
- Following careful consideration of your child's unique medical needs, this is the best procedure to answer the clinical question.
- While there are other procedures that do not use radiation, this procedure will best provide us with the information needed to inform our treatment plan.

f) Does my child need it? Does she/he need it now?

- The referring medical practitioner and radiologist have done a risk–benefit analysis for the recommended imaging procedure. They have considered alternative tests, and this specific procedure is recommended to aid in diagnosis and/or treatment of your child.
- Although some conditions may be self-limiting and tests for such conditions may be postponed, other conditions will need investigation sooner to help with the care of your child.
**Table 13. Example of message mapping in paediatric imaging**

<table>
<thead>
<tr>
<th>Stakeholder: parents</th>
<th>Anticipated question: How much radiation will my child receive from this head CT?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Key message 1</td>
</tr>
<tr>
<td></td>
<td>Key message 2</td>
</tr>
<tr>
<td></td>
<td>Key message 3</td>
</tr>
<tr>
<td>This CT is recommended now to aid in diagnosis and guide the treatment of your child</td>
<td>Your child will receive the lowest possible dose without decreasing the diagnostic quality of the images</td>
</tr>
<tr>
<td>Supporting information 1-1</td>
<td>Supporting information 2-1</td>
</tr>
<tr>
<td>We have evaluated the clinical condition of your child and agreed that we need to confirm the diagnosis to make a decision about the treatment (examples/stories)</td>
<td>There are many techniques to lower the dose without compromising the diagnosis (examples, visual communication)</td>
</tr>
<tr>
<td>Supporting information 1-2</td>
<td>Supporting information 2-2</td>
</tr>
<tr>
<td>We have considered alternative tests and agreed that this is the examination indicated for your child (referral guidelines)</td>
<td>This imaging facility uses equipment, protocols and techniques suitable for children (accreditation, audits)</td>
</tr>
<tr>
<td>Supporting information 1-3</td>
<td>Supporting information 2-3</td>
</tr>
<tr>
<td>This examination has to be done now to avoid any delay in the treatment, in case the diagnosis is confirmed (examples, scientific data)</td>
<td>This facility periodically compares its doses with national and international reference values and stays within those ranges (paediatric DRLs)</td>
</tr>
<tr>
<td>Supporting information 3-1</td>
<td>Supporting information 3-2</td>
</tr>
<tr>
<td>The radiation dose will be small, similar to several months of exposure to natural background radiation (analogies, tables, visual communication)</td>
<td>The radiation risk is low and the likelihood of an adverse outcome (cancer risk) will be nearly the same as it is for any other child: lifetime cancer incidence risk of 35-40% (analogies, tables, pictorial resources for visual communication)</td>
</tr>
<tr>
<td>Supporting information 3-3</td>
<td>The CT will be interpreted by imaging specialists trained to identify abnormalities and their significance. The report will be communicated to the referring physician who will make decisions about treatment and follow-up (stories, examples)</td>
</tr>
</tbody>
</table>
3.2 Ethical considerations

This section emphasizes the importance of an effective radiation risk communication to support the informed decision-making process in paediatric imaging from an ethical perspective, discussing the principles rather than the legal implications.

Based on the principles of non-maleficence and beneficence (i.e. first do no harm and secondly do good) health professionals have an ethical responsibility to optimize the risk-benefit ratio of all interventions. The obligation to benefit the patient must be balanced against the obligation not to cause harm, with the purpose of ensuring that the benefits will outweigh the harm (Sokol, 2013). Applying these ethical principles may become a difficult
Creating a dialogue in the medical community: scenarios and players
Derivative tools targeting patients/parents

- Derivative communication tools based on the document are being currently developed to support benefit-risk dialogue in pediatric imaging.
- Content: general information, specific information for different disciplines.
- Format: leaflets, posters, infographics.
Currently under development

Dental imaging: to be developed in collaboration with the FDI/International Dental Federation and the IAEA
Global efforts for improving radiation protection in medicine

Bonn Call for Action

10 actions to improve radiation protection in medicine in the next decade

1. Enhancing implementation of **justification** of procedures
2. Enhancing implementation of **optimization** of protection and safety
3. Strengthening manufacturers’ contribution to radiation safety
4. Strengthening RP **education and training** of health professionals
5. Shaping & promoting a **strategic research agenda** for RP in medicine
6. Improving **data collection** on radiation exposures of patients and workers
7. Improving primary **prevention of incidents and adverse events**
8. Strengthening radiation **safety culture** in health care
9. Fostering an improved radiation **benefit-risk-dialogue**
10. Strengthening the implementation of safety requirements (**BSS**) globally

[Links to related resources]
International Conference on Radiation Protection in Medicine - *Achieving Change in Practice* (Vienna, Austria, 11–15 December 2017)

- Organized by the IAEA, co-sponsored by WHO and PAHO
- Advanced work including the development of the scientific programme, identification of speakers, review and classification of submitted papers.
Thank you very much!

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