

From X-rays to AI: 20 Years of Radiation Protection in Medicine and Beyond




27 August 2025

Hanne Waltenburg

NSFS XX Conference, Lillehammer, Norway


NSFS conferences and the medical field

 STUK-A195 / JUNE 2003

SESSION 7. RADIATION IN MEDICAL USE
Medical use of ionising radiation – challenges for the third millennium

Wolfram Leitz
Swedish Radiation Protection Authority, SE-171 16 Stockholm

Turku/Åbo, Finland
August 25 - 29, 2002

 **Diagnostic reference levels**

Radiation Protection in Transition
Regular Meeting of the
Protection, NSFS
-31 August 2005
Nordic Society for Radiation Protection
Rättvik, Sweden

**Interventional radiology
Eye lens doses**

of the NSFS XV conference in
26-30 of May 2008
Statens
Norwegian Radiation Protection

 **NSFS Conference** **Population doses** **22-25 August 2008**
Challenges in Radiation Protection

XVII CONFERENCE OF THE NSFS
ROSKILDE DENMARK

INVITED: Developments and justification of applications using ionizing radiation in the medical field

Steve Ebdon-Jackson, Public Health England, Medical Exposure Regulatory Infrastructure Team

2019 **Interventional radiology and cardiology** Conference

“Next Level in Radiation Protection”

Nuclear medicine

NSFS XIX Conference, June 5-9, 2023
“Sharing and caring”

+ 

Common topics

- Justification
- Optimisation
- Dose limitation
 - Not for patients, but for staff and public



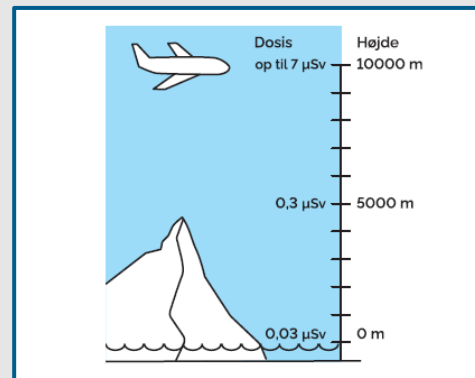
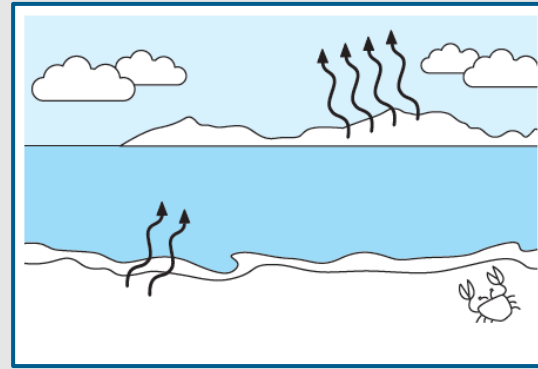
- Justification
 - Clinical audit
 - New technologies
 - Interface to Health technology assessment
- Optimisation
 - Dosimetry
 - Diagnostic reference levels
 - Paediatric examinations
 - Personnel doses
 - Quality assurance
- New(er) technologies
 - Intravascular brachytherapy (2002)
 - Dental CBCT (2011)
 - Proton Therapy (2015)

Medical – the largest man-made contribution

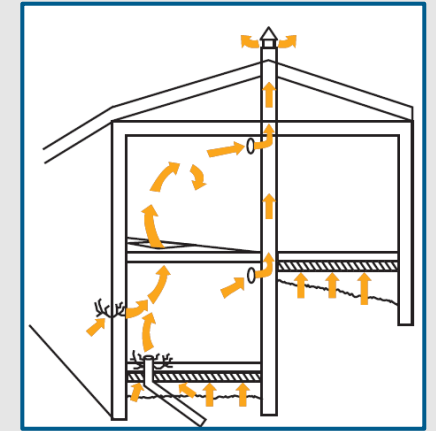
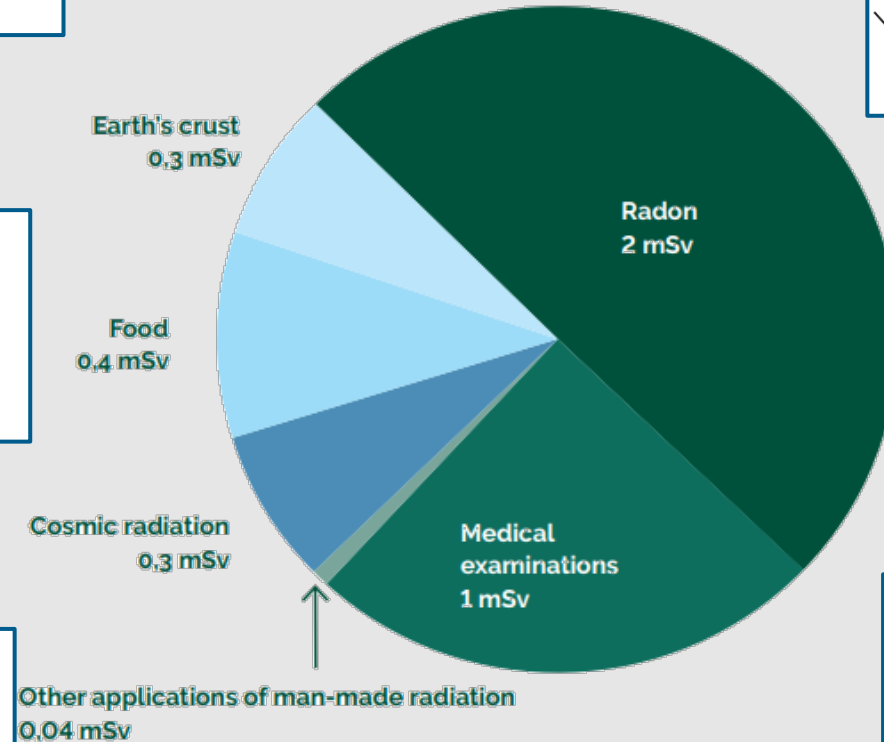
Average dose to residents in Denmark

- Large study in the 90's
 - Medical: 0,5 mSv
- Estimation in 2015
 - Medical: ≈ 1 mSv

[Radiation – a part of your everyday life](#)
Danish Health Authority, 2024

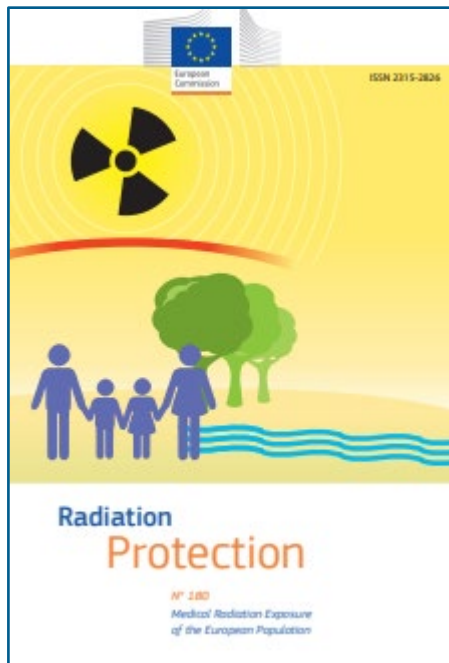


74 % natural
26 % man-made

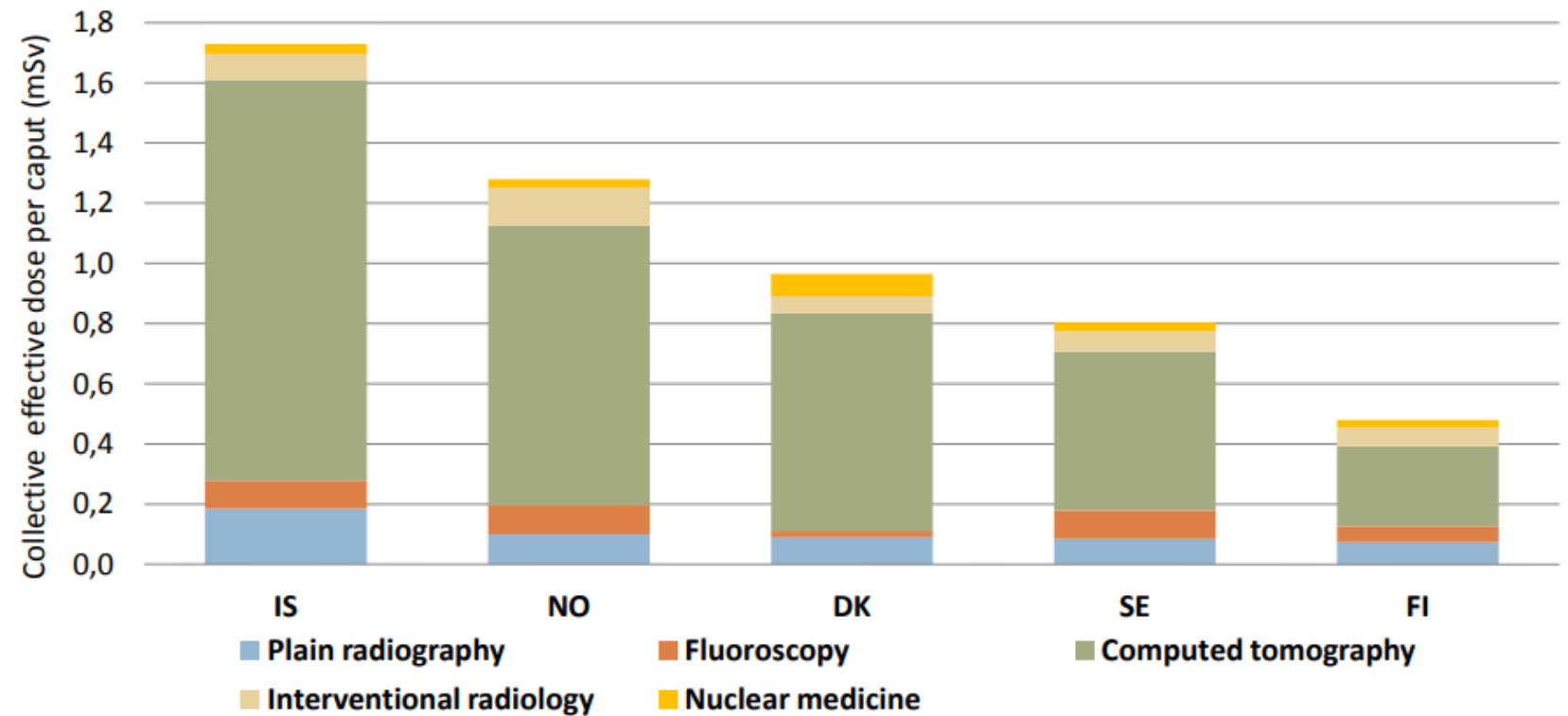


Nordic countries

- Collective effective doses from medical procedures
- From DoseDatamed 2 (EU) project



COLLECTIVE EFFECTIVE DOSES



SÄTEILYTURVAKESKUS • STRÅLSÄKERHETSCENTRALEN
RADIATION AND NUCLEAR SAFETY AUTHORITY



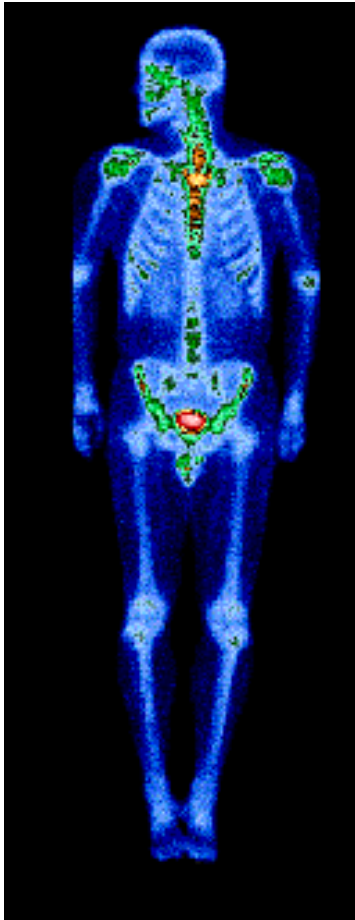
[Population doses from x-ray and nuclear medicine procedures in Nordic countries](#)

Ritva Bly (STUK)

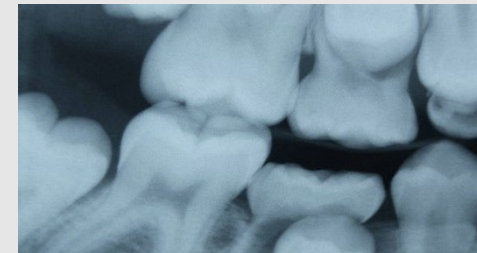
NSFS conference 2015



Medical exposures in Denmark



- Medical examinations and treatments – numbers per year
 - 4,2 mio. X-ray examinations in hospitals etc. (2023)
 - 2,6 mio. conventional/fluoroscopy
 - 1,3 mio. CT
 - 0,3 mio. mammography screening
 - 173.000 Nuclear medicine examinations (2023)
 - 89.000 PET
 - 84.000 Other
 - 53.000 X-ray examinations at chiropractor (2010)
 - 4,1 mio. X-ray examinations at dentists (2005)
 - 20.800 Persons in radiation and NM therapy (2016)
 - ? Persons treated at private dermatology clinics

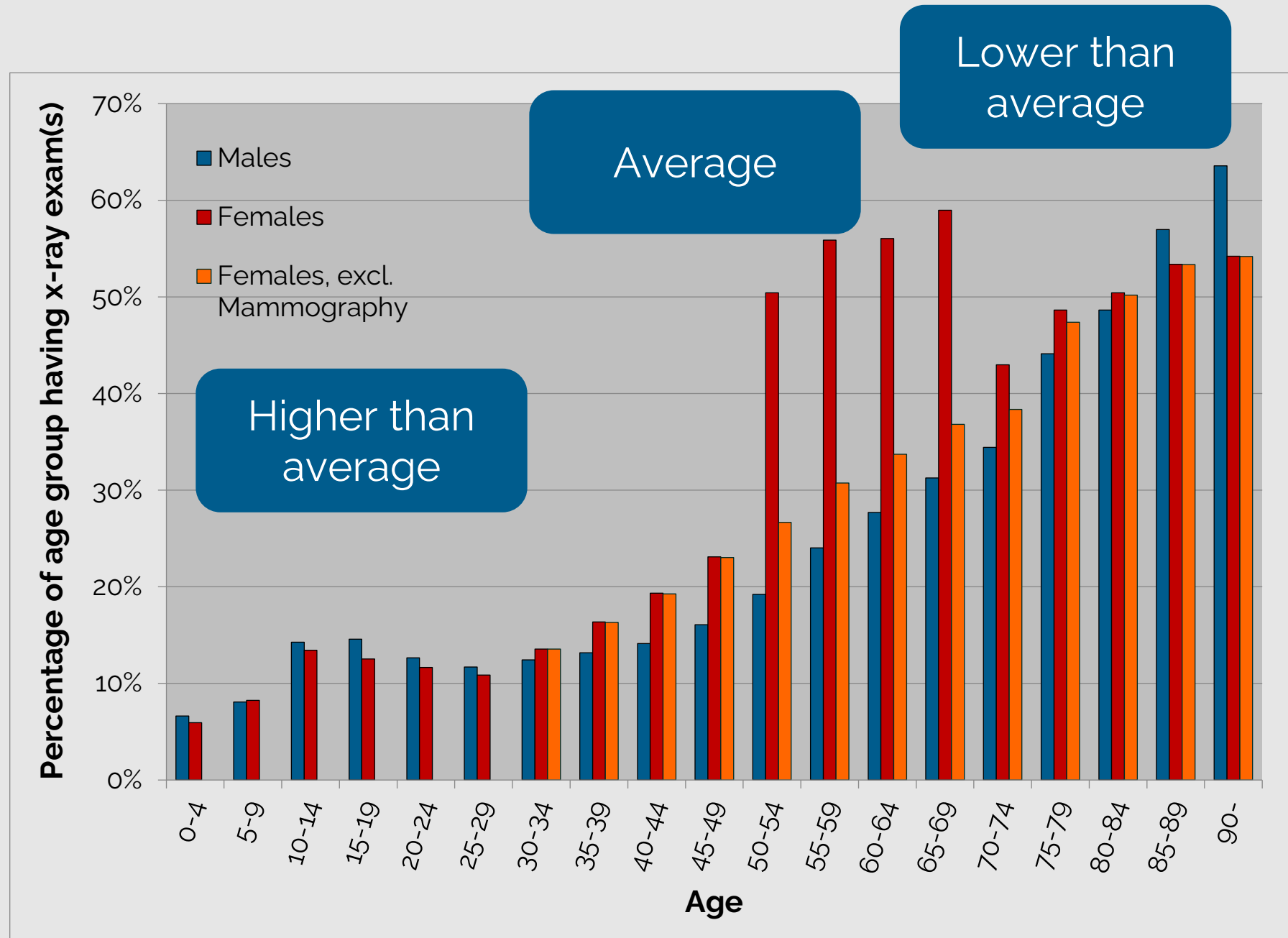


Average is not everybody

- In Denmark:
 - Overall about 25% of the population has an x-ray within a year
 - 8% have a CT
- Unevenly distributed among age groups

Radiation risk

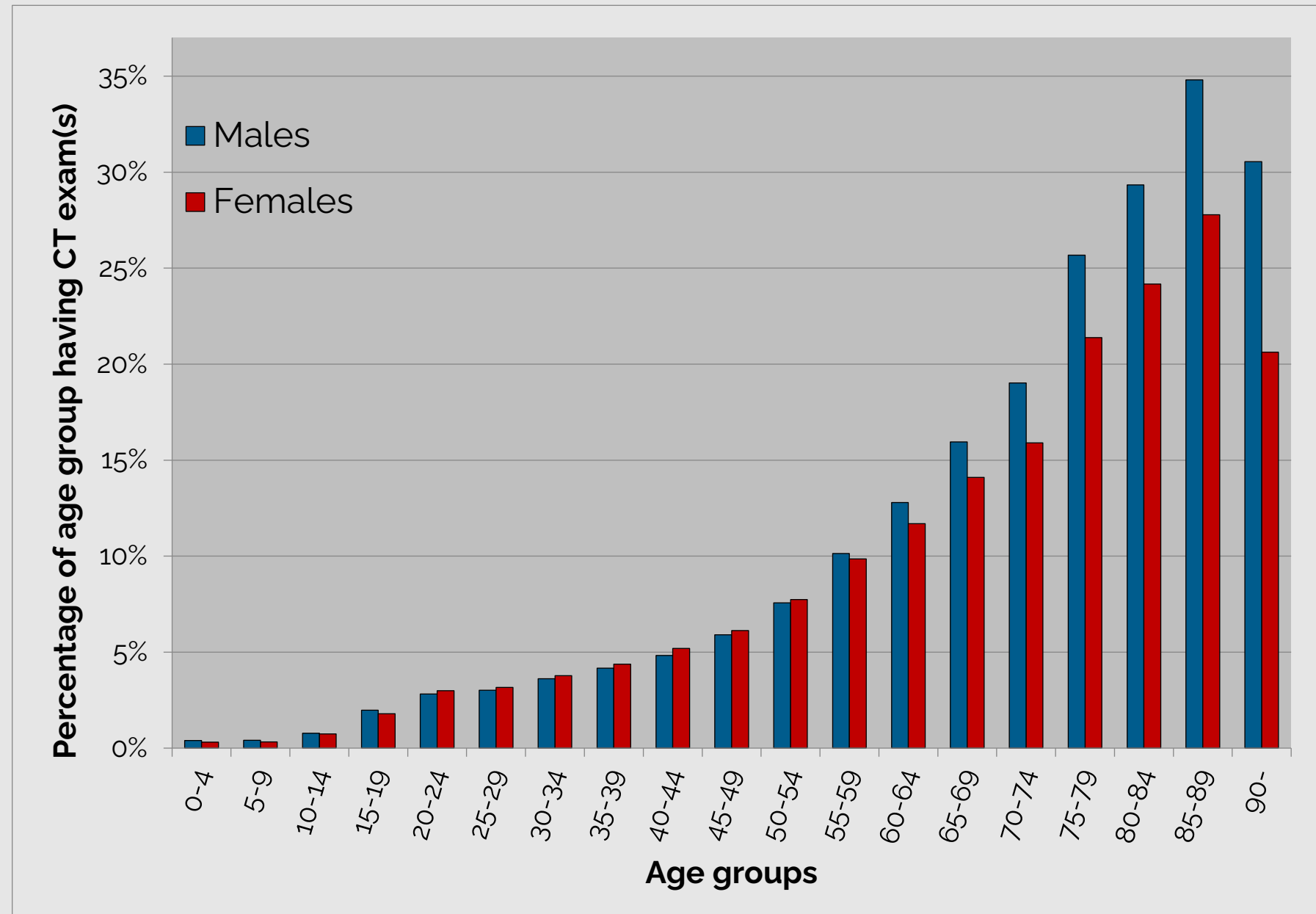
- All types of examinations, incl. CT
- National Patient Registry, Denmark, 2021



CT – even more skewed

- Age group 0-19 years:
 - 1,6% of all CTs
 - 6,1% of all MRs

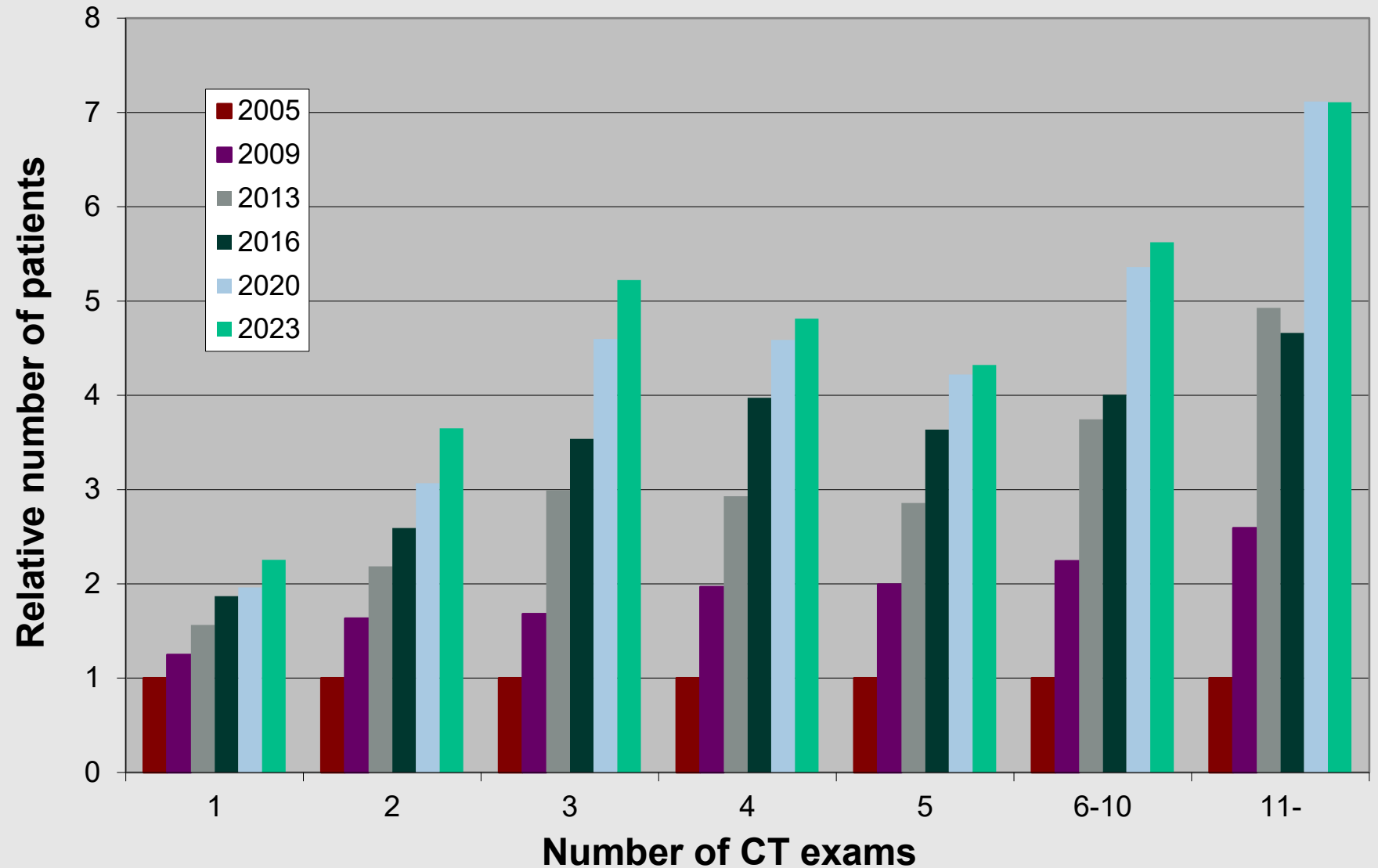
- National Patient Registry, Denmark, 2021/2022



Many patients get more than one CT

- More than 10 CTs pr. year
 - 2005: 1.300 pt.
 - 2023 9.400 pt.

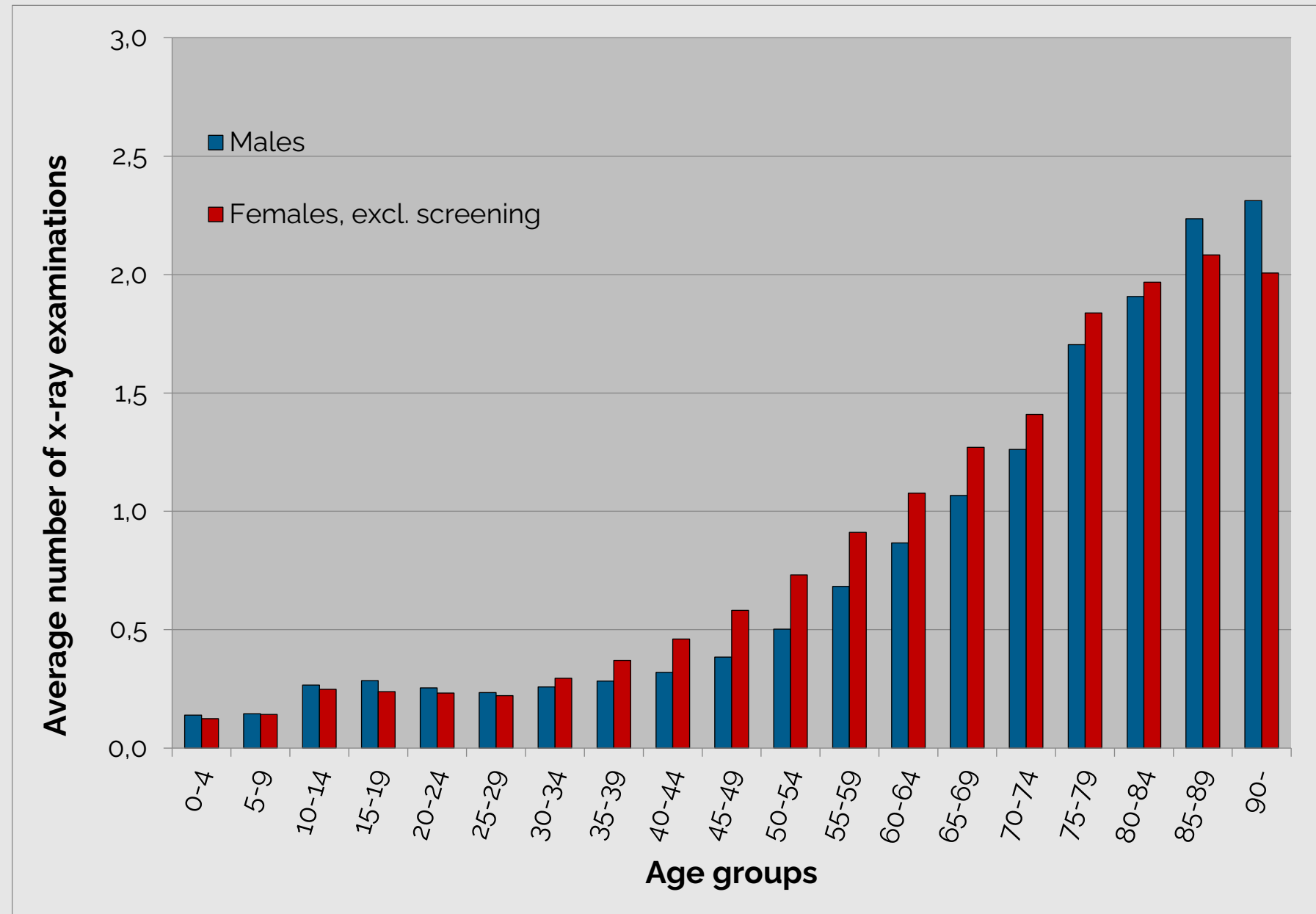
- National Patient Registry, Denmark, 2005-2023



How many exams per person per year ?

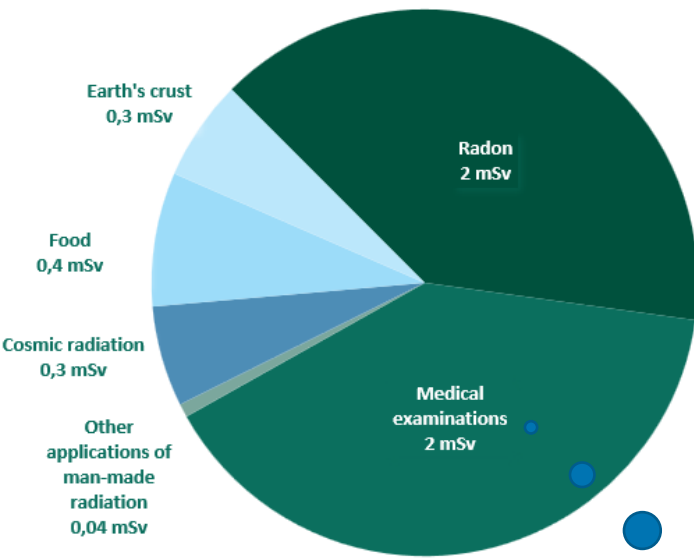
- Average for the entire population

- All types of examinations, incl. CT
 - Except mammography screening
- National Patient Registry, Denmark, 2021

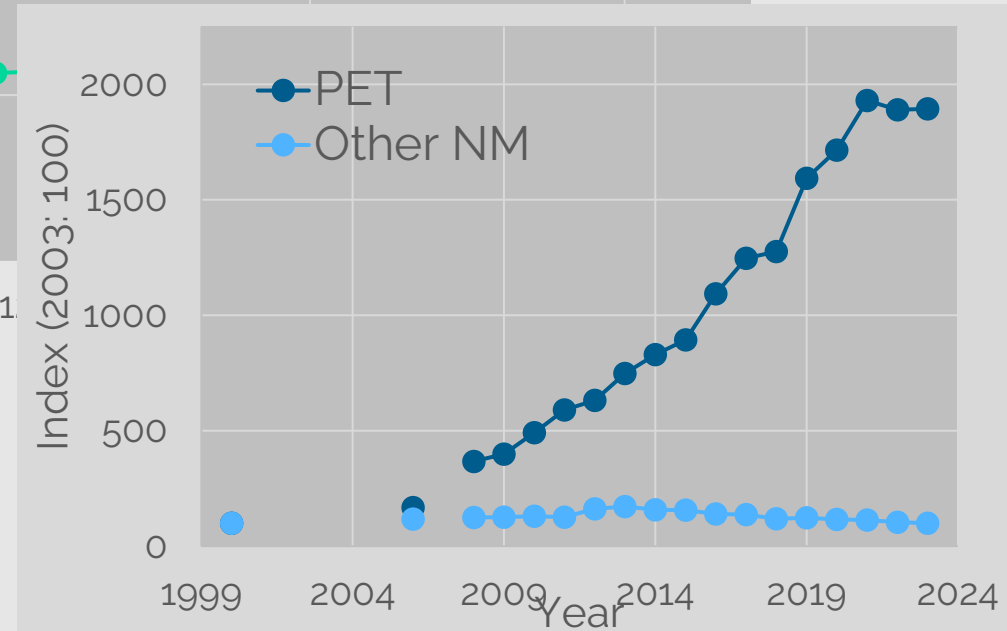
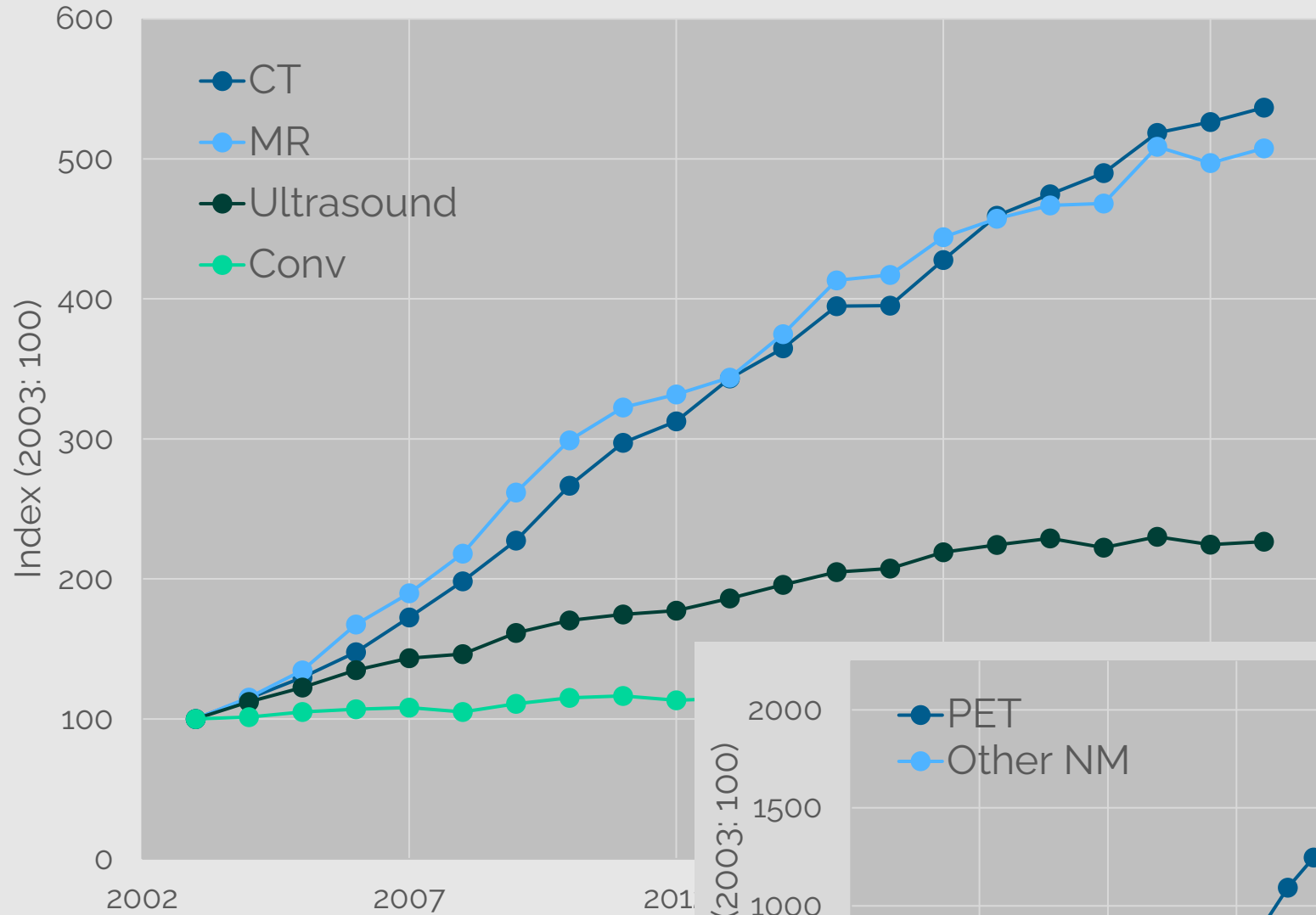


Contribution still increasing

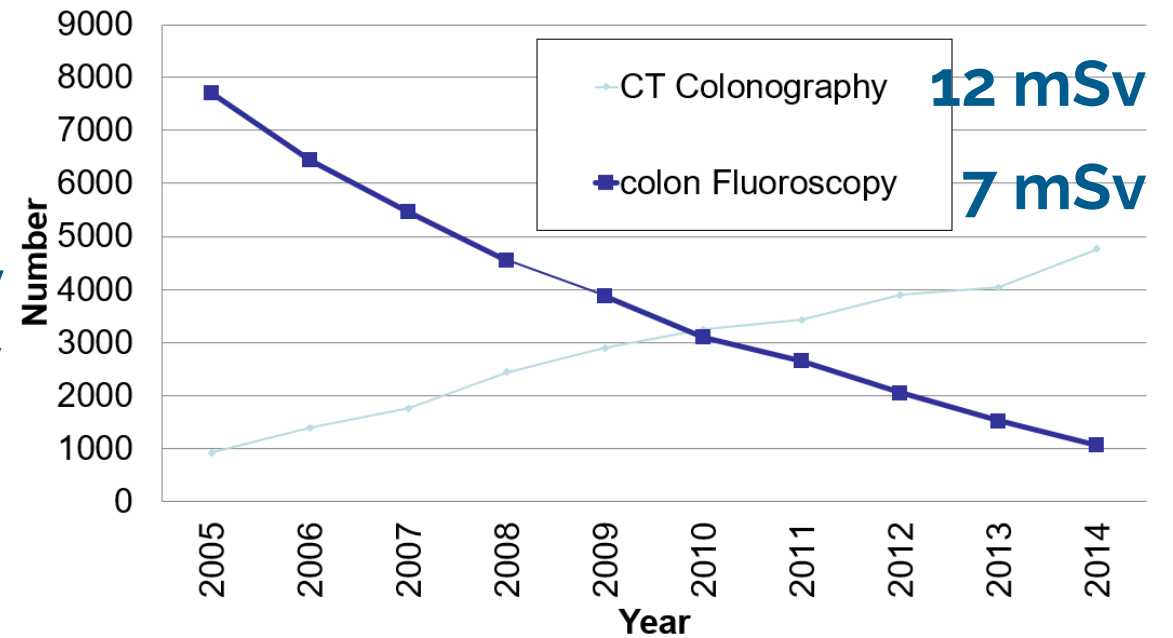
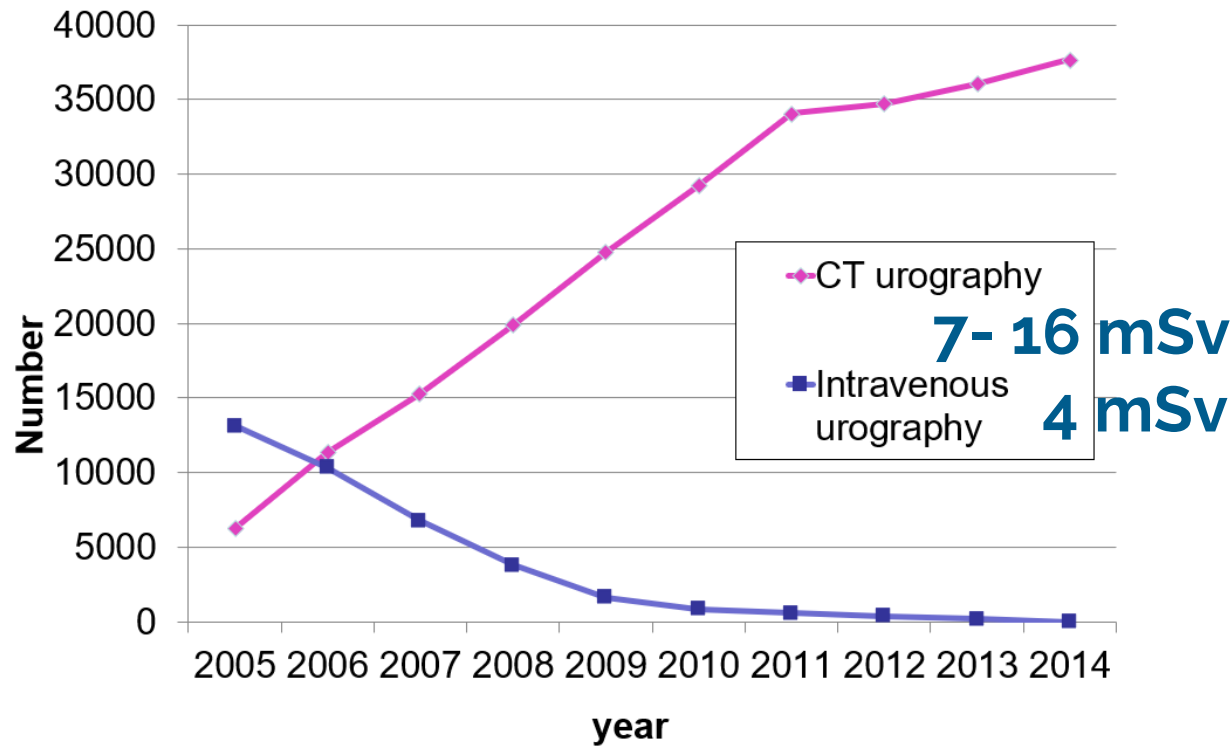
- New preliminary estimate, Denmark (2024)



≈ 80 % from CT



CT replacing conventional x-ray examinations



Developments in first choice from conventional X-rays to CT for selected studies
 Britta Højgaard, Hanne Waltenburg (SIS)
 NSFS conference 2015



Improved diagnostic capabilities drives the increase

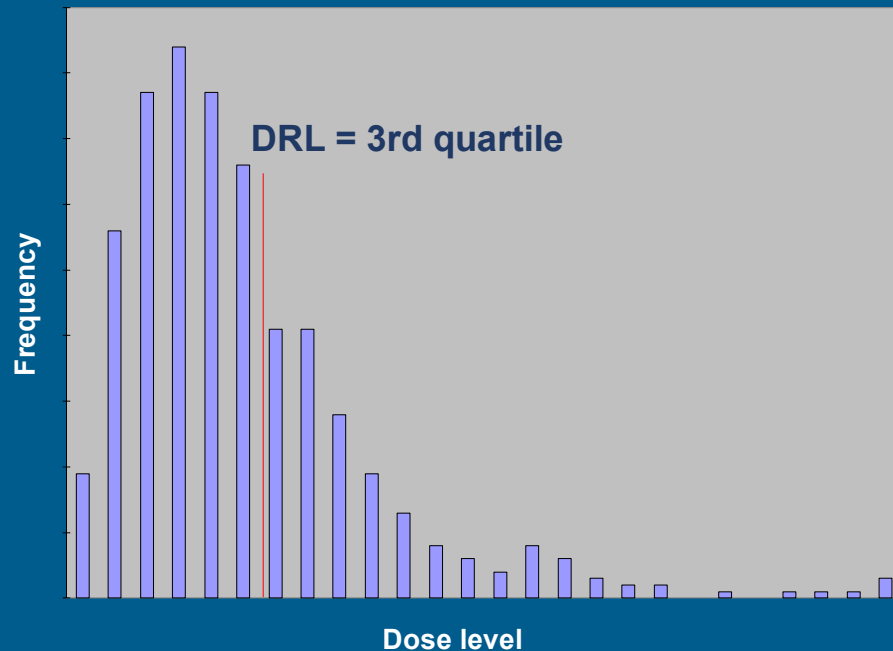
- Together with aging population etc.

..., but still concerns about justification

- Key findings from EU-JUST-CT study
 - **Awareness** of legal aspects of radiation protection and justification still **needs to be increased** among Member States.
 - The **appropriateness rates** of the scored referrals in the seven pilot countries/regions **varied between 57.9% and 85.9%**, showing a large disparity between countries and the need for further action to improve justification of CT examinations.
 - The proportion of examinations whose appropriateness could not be assessed because of **no or insufficient clinical data** also varied considerably between countries (from 0.3% to 27%).
 - ...
 - EU-JUST-CT: European co-ordinated action on improving justification of computed tomography [EU RP no. 205, 2024](#)

Diagnostic reference levels

- Definition (EURATOM)
 - dose levels in medical radiodiagnostic or interventional radiology practices, or, in the case of radio-pharmaceuticals, levels of activity, for typical examinations for groups of standard-sized patients or standard phantoms for broadly defined types of equipment



What about dose levels ?

Decreasing levels in general

- Technological advancements
 - **Better detectors**
 - Dose modulation in CT
 - New reconstruction algorithms
 - New target and filter materials
- More focus and understanding
 - Collimation
- More difficult to assess due to differences in patient size
 - Especially for paediatric patients

Conventional X-ray

Has decreased even further since then

Sundhedsstyrelsen
National Board of Health

Diagnostic reference levels for diagnostic x-ray examinations in the Baltic and Nordic countries

HN Waltenburg†, R Bly, T Cederlund, G Einarsson, EG Friberg, H Järvinen, W Leitz, K Muru, A Widmark, J Ziliukas

Background

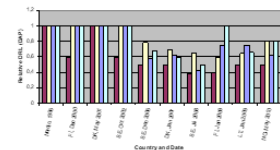
The European directive on medical exposures requires member states to promote the establishment and use of Diagnostic Reference Levels (DRLs), and that Denmark, Finland, Sweden and all of the Baltic countries are required to establish DRLs. DRLs were introduced in the Nordic countries through a common set of recommended values for four conventional and two fluoroscopic examinations, published in 1996 by the Nordic Working Group on X-ray Diagnostic Substitution between the five Nordic countries. In the Baltic countries, DRLs were introduced in Lithuania 3 years ago, while Estonia are currently setting national DRLs.

Material and Methods

Based on collaboration between the Nordic Working Group on X-ray diagnostic and representative from the radiation protection authorities in Estonia and Lithuania previous and current national DRLs from the 7 countries have been collected. The DRLs have been taken from the national guidelines and from results of dose surveys carried out by the authorities. Estonia does not have national DRL values set. Lithuania has national DRL values set for the most typical examinations, while the rest of parameters in the Baltic countries have no national DRLs set, and has not been included in the table. The last figure shows members of the DRLs have been low being set and revised as well of relative values. For conventional fluoroscopy and CT examinations, respectively. The examinations included in the figure are those, where most countries have set DRLs.

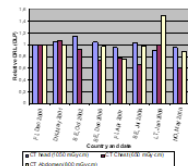
Number of examinations for which DRLs have been set. In cases where more than one type of DRL has been set for each type of examination, the number in parentheses shows the total number of DRLs.

Country	Adult patients					Paediatric patients
	Contra.	Fluorosc.	Cardiac	CT	Mammogr.	
Denmark (DK)	4	1	3	1	1	4 (6)
Finland (FI)	51 (12)	1	2 (4)	4 (9)	1	3 (6)
Iceland (IS)	4 (6)	2				
Lithuania (LT)	7 (22)	3 (6)		5	1	
Norway (NO)	6	1	1	10 (20)	2	
Sweden (SE)	4	1	1	4 (8)	2 (4)	
Average			14 (22)			



Findings

The number and type of examinations for which diagnostic reference levels have been set and the values of the DRLs have been compared between the latest countries in the table. The table shows the number of currently valid national DRLs in the different countries. The table number shows the number of different examinations for which DRLs have been set. In some countries, DRLs for several quantities (e.g. chest DRL and lumbar spine DRL) have been set for the same type of examination, with the number in parentheses in the table below. In Estonia and Lithuania no national DRLs are set, and has not been included in the table. The last figure shows members of the DRLs have been low being set and revised as well of relative values. For conventional fluoroscopy and CT examinations, respectively. The examinations included in the figure are those, where most countries have set DRLs.



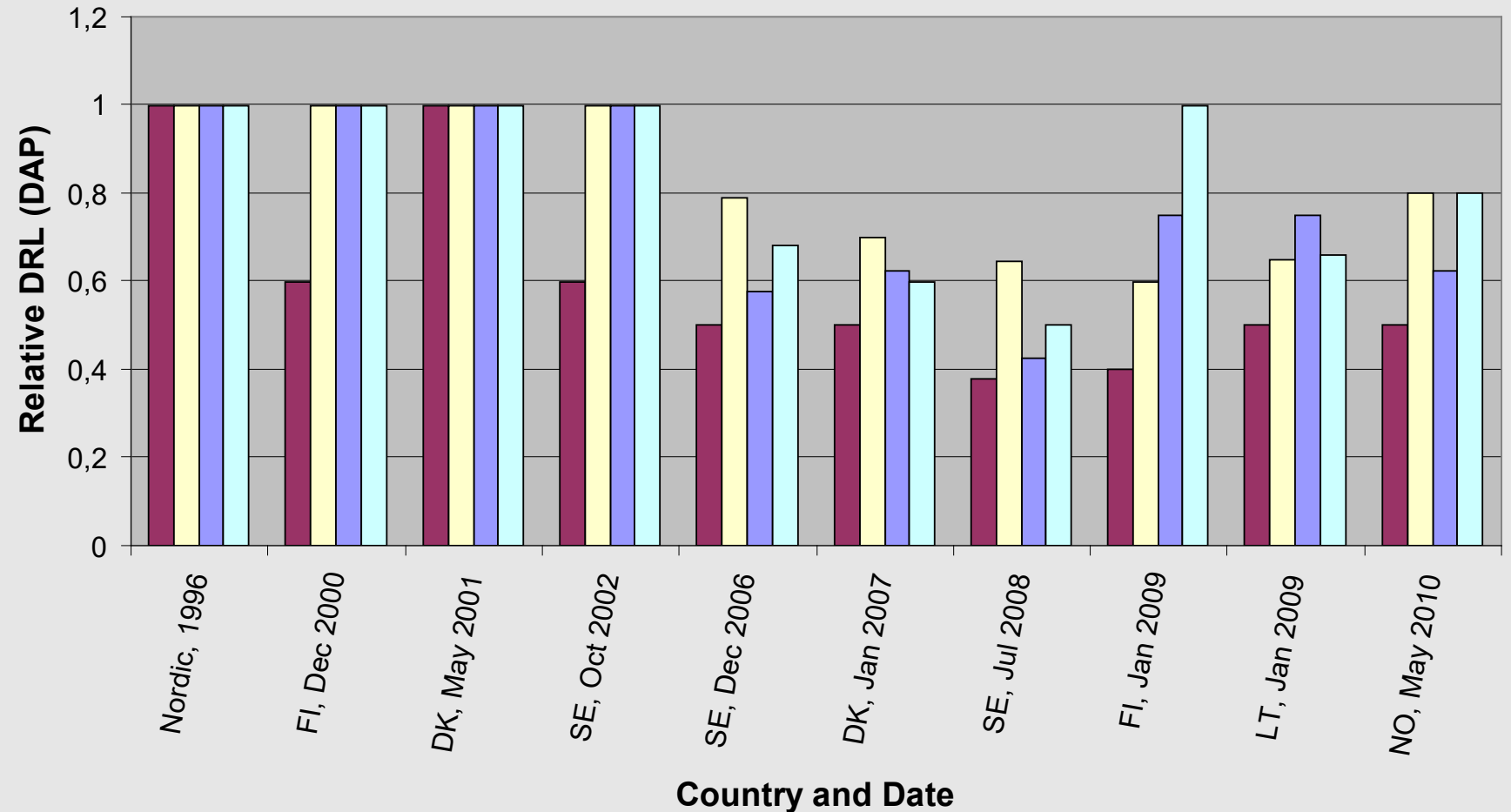
Development of the value of DRL (total DAP for the examination) for three conventional and two fluoroscopic examinations. The value of each DRL is given relative to the value of the original common Nordic DRL (shown in the legend).

Conclusions

The number of examinations for which DRLs have been set as well as the total number of DRL values vary considerably between the different countries. The number of DRLs for examinations of adult patients varies between 1 and 2, with an average of 2. The development of the DRL values in the Nordic countries has been quite similar over time, although there are also some differences between the countries. For conventional examinations, the possibility also the focus on optimization during this period. For the fluoroscopic examinations, represented by chest fluoroscopy, the decrease in relative value is unexpected. For CT, the DRL values have been quite constant, except for CT chest where the recent values from Sweden and Norway are 40% to lower than earlier values.

The DRL values from the two Baltic countries, Lithuania and Estonia from around 2005 were generally higher than the values from the Nordic countries, especially the Lithuanian DRL for the chest CT examination, which was 20% to higher, however, the recent DRL from Lithuania are much lower and the conventional and fluoroscopic examinations (apart from the recently set Norwegian values). For CT, the recent DRLs from Lithuania are still somewhat high, especially the DRL for CT colonography, which is 50% higher than the Nordic values.

† Corresponding Author: Hanne N. Waltenburg
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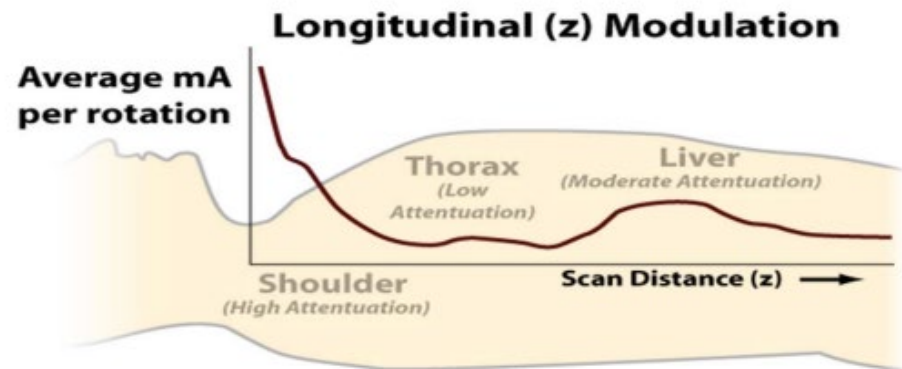


Diagnostic reference levels for diagnostic x-ray examinations in the Baltic and Nordic countries
HN Waltenburg†, R Bly; T Cederlund; G Einarsson; EG Friberg; H Järvinen; W Leitz; K Muru; A Widmark; J Ziliukas
IRPA Europe conference 2010



CT dose levels are decreasing less

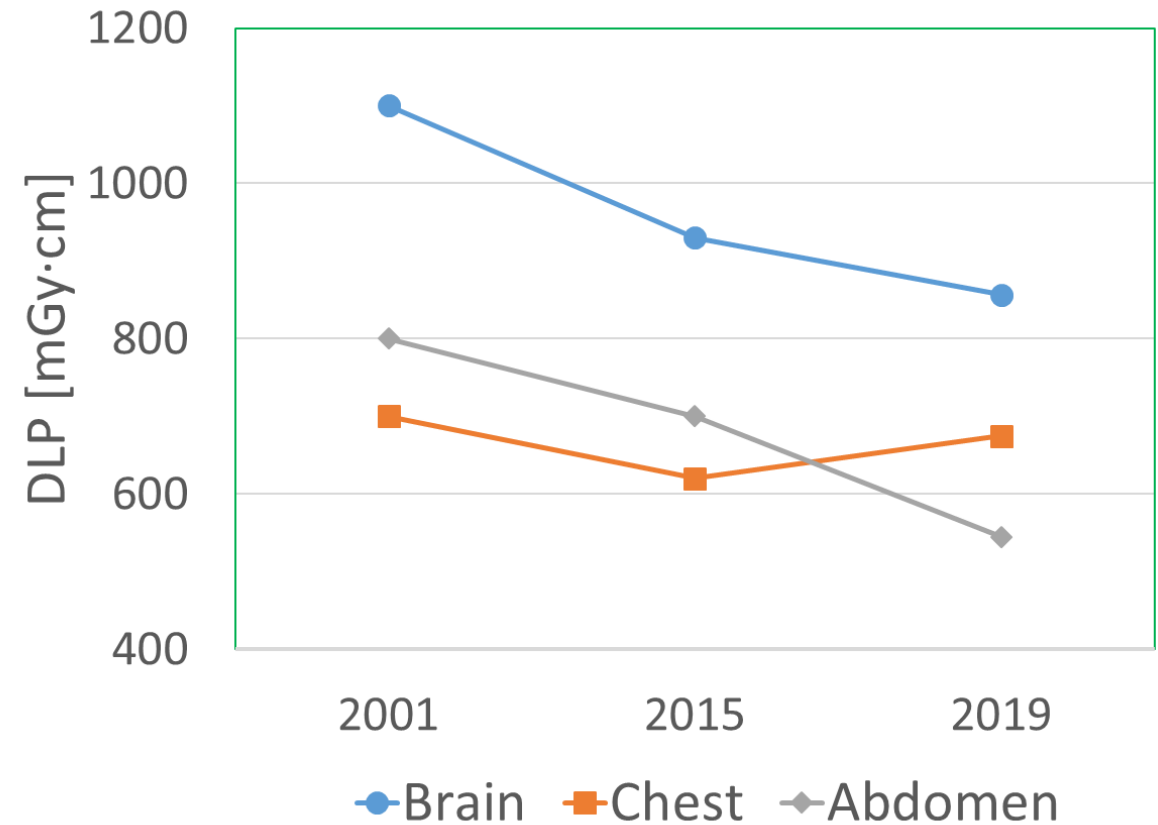
- Intense development of scanners
 - Single slice → multi-slice (e.g. 4) → MDCT (64, 128, 320 ...)
 - Tube current modulation*



- Beam-shaping filters
- Iterative reconstruction
- Dual-Energy CT
- **Hybridscanners (PET-CT etc.)**
- Mainly used to improve performance
 - Advanced applications, e.g. cardiology
 - Better resolution

* [AAPM WGCTNP Dose Education Slides](#)

DRL over time for selected CT exams

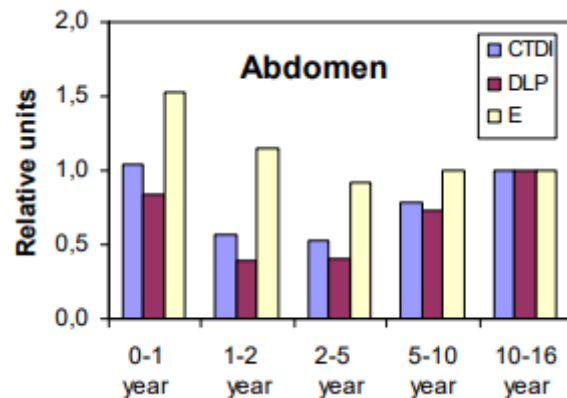


Development of national diagnostic reference levels for CT in Denmark
B Højgaard, HN. Waltenburg
NSFS Conference 2019

Children are not small adults

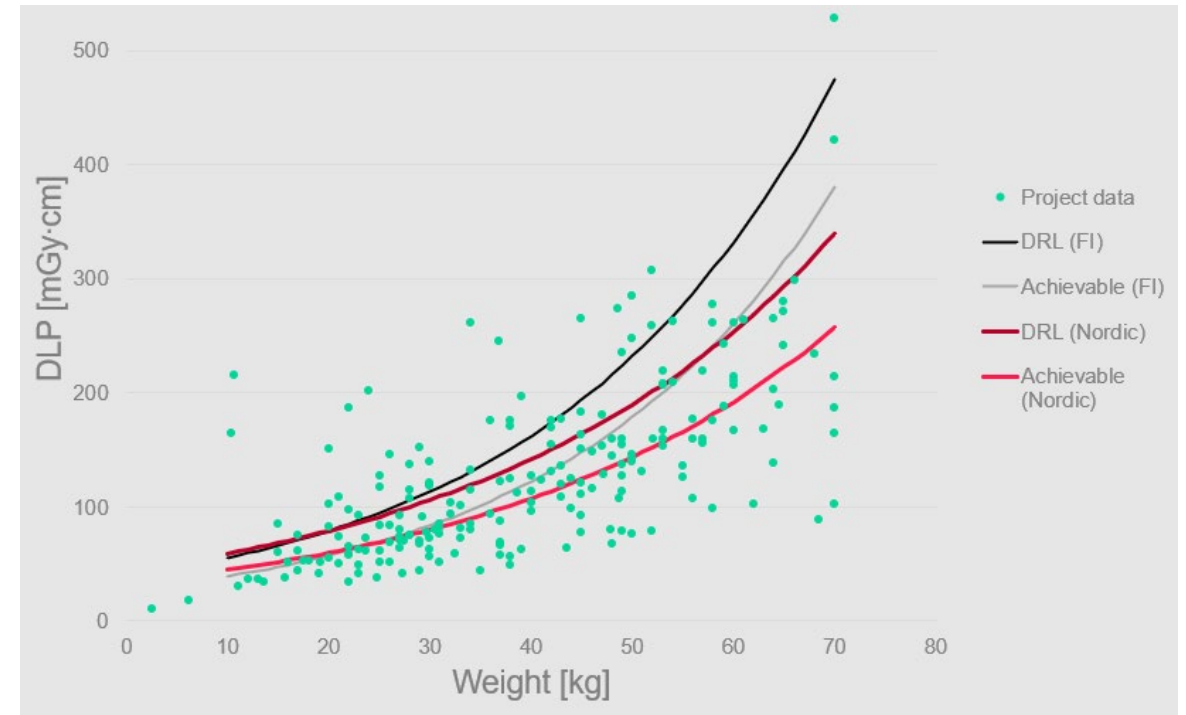
2008 – Doses from pediatric CT examinations and level of optimization of the scan protocols in the Nordic countries

- The lack of size-specific scan protocols for pediatric patients.
- Possible to reduce the mAs-values without undue loss of diagnostic information
 - ⇒ significant dose reduction to the pediatric patient.



EG Friberg, A Almen, G Einarsson, H Järvinen, W Leitz, HN Waltenburg, R Bly
NSFS Conference 2008

2019 – Nordic project: Establishing diagnostic reference levels for pediatric patients



HN Waltenburg, B Højgaard, T Cederlund, A Almén, R Bly, P Tenkanen-Rautakoski, N Heimland, A Widmark, N Pétursdóttir
NSFS Conference 2019

Looking into the future – Opportunities and Challenges

- Artificial Intelligence
 - Diagnostic imaging
 - Postprocessing of images, describing images, quality control of equipment
 - Radiotherapy
 - Contouring
 - Regulatory authorities
 - Assisting in reporting on inspections
 - Big data for everyone
 - Diagnostic reference levels
- Photon-counting CT
 - Better image quality with lower doses?
- Nuclear medicine
 - Many new radionuclide therapies
 - Tools for optimisation to the individual patient missing

HEALTH

SciTechDaily

Only 2% the Radiation Dose: New AI Technology Revolutionizes CT Scans

BY RADIOLOGICAL SOCIETY OF NORTH AMERICA – MARCH 13, 2025 NO COMMENTS 5 MINS READ

<https://scitechdaily.com/only-2-the-radiation-dose-new-ai-technology-revolutionizes-ct-scans/>
<https://pubs.rsna.org/doi/10.1148/ryct.240189>



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Advances in Nuclear Medicine Mean Patient Protection Needs Strengthening

Joanne Burge, IAEA Department of Nuclear Safety and Security

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Winning poster for the upcoming International Day of Medical Physics (IDMP)

<https://www.iomp.org/idmp-2025/>

International Day of Medical Physics

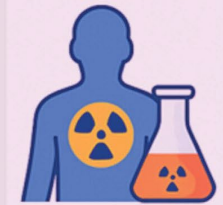
Medical Physics and Emerging Technologies:
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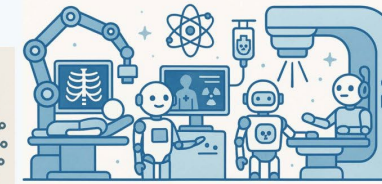
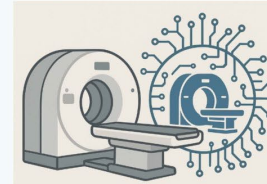


Proton Therapy

Theranostics



Digital Twin Model
of SPECT-CT

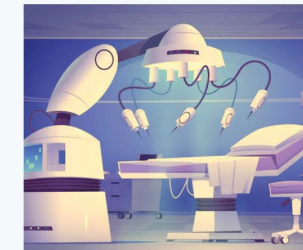


ROBOTICS IN RADIOLOGY, NUCLEAR MEDICINE
AND RADIOTHERAPY

PET - MRI



3D Printing
Phantoms



Cyberknife

Telemedicine



Celebrating innovation and impact — Advancing healthcare
through Medical Physics and Emerging Technologies.

Important topics in radiation protection in medicine – when asking an AI



Thank
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the
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