Livelong accumulated radiation exposure dose from medical radiography and nuclear medicine in a population representative sample

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Overview

- Diagnostic radiography is a leading cause of man-made radiation exposure. Individual and population based radiation risk assessment require retrospective assessment of lifelong exposure from medical sources.
- The prevalence of radiologic examinations and the resulting cumulative red bone marrow dose are presented in a population based retrospective epidemiologic study.

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1. Introduction

- Diagnostic radiography is the most important single source of exposure to ionizing radiation in the general population. Presently, radiography contributes some 40% to the overall radiation exposure.
- However, presently both the population based lifelong prevalence of radiologic examinations and the resulting cumulative radiation doses are unknown.

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Red bone marrow dose

- The red bone marrow dose is the place of origin of leukemia – a group of diseases that can be caused by radiation.
- Compared to other diseases caused by radiation exposure leukemia develops after lower doses and with shorter latency following exposure.
- Thus the <u>cumulative red bone marrow dose</u> is an important factor when dealing with risk estimations and causes of leukemia.

2. Data base: Population based representative cohort (2811 subjects)

- The lifetime dose of the red bone marrow from different kinds of radiologic examinations was estimated on a population based representative cohort (2811 subjects), who served as controls in the Northern Germany Leukemia and Lymphoma Study (NLL) – a large population-based epidemiologic case control study conducted in Northern Germany (Hoffmann et al 2008).
- In the study were included conventional radiography including chest x-ray screening examinations, fluoroscopies with contrast medium, catheter examinations, and interventions; examinations with computer tomography, and nuclear medicine examinations.
- The personal interviews were administered in a standardized, computerized way considering number, calendar year and kind of each examination as well as gender and age of the subjects.

Hoffmann W et al. Am J Ind Med 51 (2008) 246-257.

3. Algorithm

- The calculations are based on the comprehensive quantification model suggested by von Boetticher and Hoffmann (2007) which include
  - calendar year
  - age
  - kind of examination
  - gender of the subjects
  - technical development
  - real life conditions of radiological practice

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Dose assessment procedure: 3 consecutive steps

(1) Assessment of a set of ideal doses measured under optimum conditions (reference time period 1976-1985)

(2) Correction for the state of radiologic technology at the time of a respective exposure (under optimum conditions)

(3) Correction for the prevailing standard of radiologic practice

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von Boetticher H, Hoffmann W. Health Phys 2007; 92: 315-331

Example of correction for the time of a respective exposure (x-ray examinations)

Correction factors for x-ray examinations on the basis of the development of the film-screen imaging system

Time period	Required dose for film/screen imaging system (µGy)	Relative dose factor (reference period 1976-85)
1946-55	40 - 80	**8**
1956-65	20 - 40	**4**
1966-75	10 - 20	**2**
1976-85	5 - 10	**1**
1986-95	2,5 - 5	**0,5**

from: Bauer 1943, Traut 1952, Spiegler 1955, Janker 1956, Schott 1970, Rödel 1977, Ewen 1980, Drexler 1985, Bundesärztekammer 1989

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Coefficients for the standard of radiological practice (conventional x-ray examinations)

Standard	Radiologic practice	Relative dose factor
A	optimum / idealized	**1**
B	lower realistic patient exposure	**2**
C	medium realistic patient exposure	**4**
D	upper realistic patient measure	**8**

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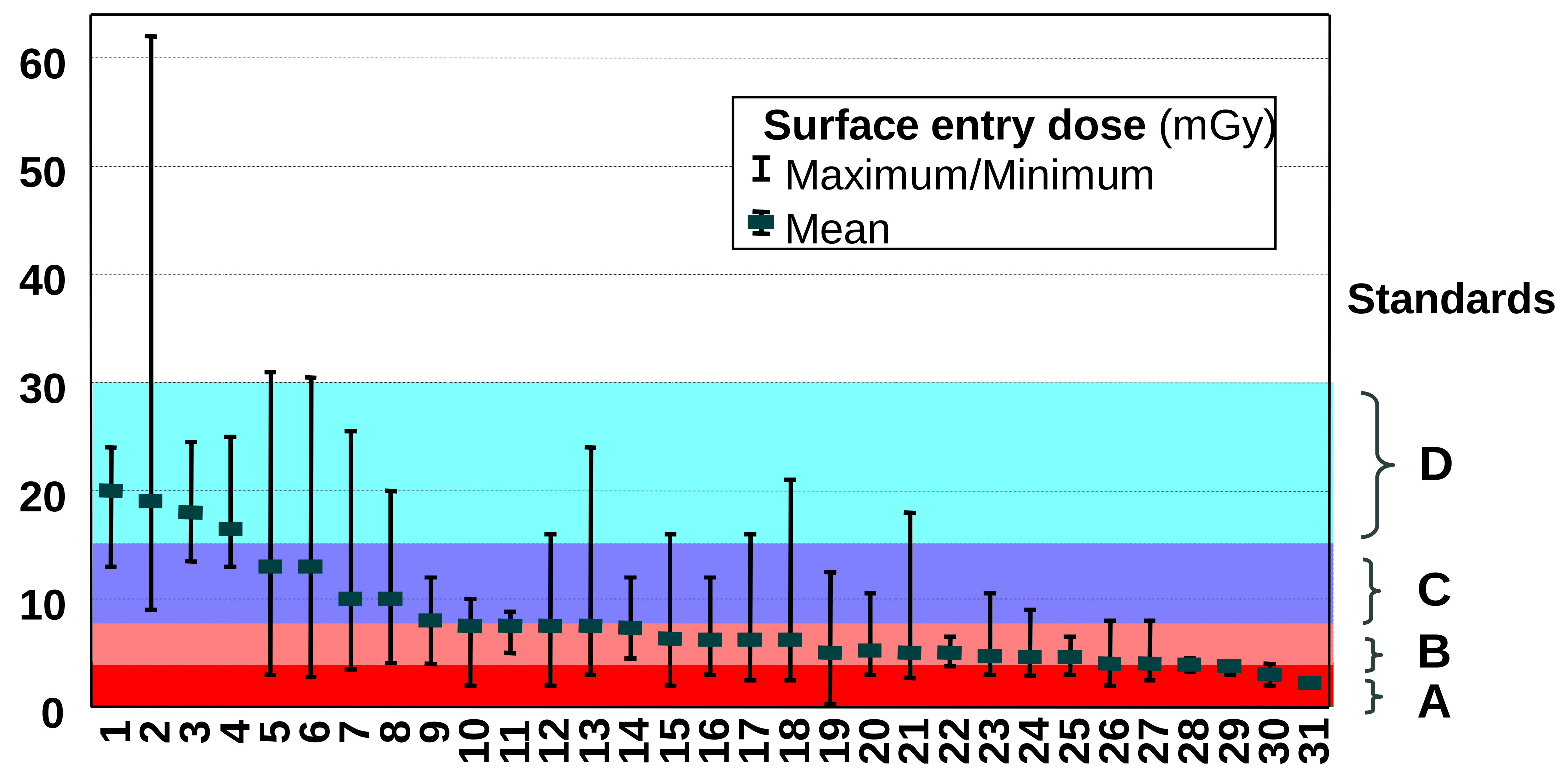
Example for the coefficients A-D for the standard of radiological practice



Variation of patient surface entrace doses (conventional x-ray of the lumbal spine, ap/pa-projection) in 31 hospitals (after Schibilla 1995)

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Example: Prevailing standard of radiologic practice (conventional x-ray examinations)

Time period	Standard of radiologic practice A	B	C	D
1946 – 1955	**8**	**16**	**32**	**64**
1956 – 1965	**4**	**8**	**16**	**32**
1966 – 1975	**2**	**4**	**8**	**16**
1976 – 1985	**1**	**2**	**4**	**8**
1986 – 1995	**0,5**	**1**	**2**	**4**

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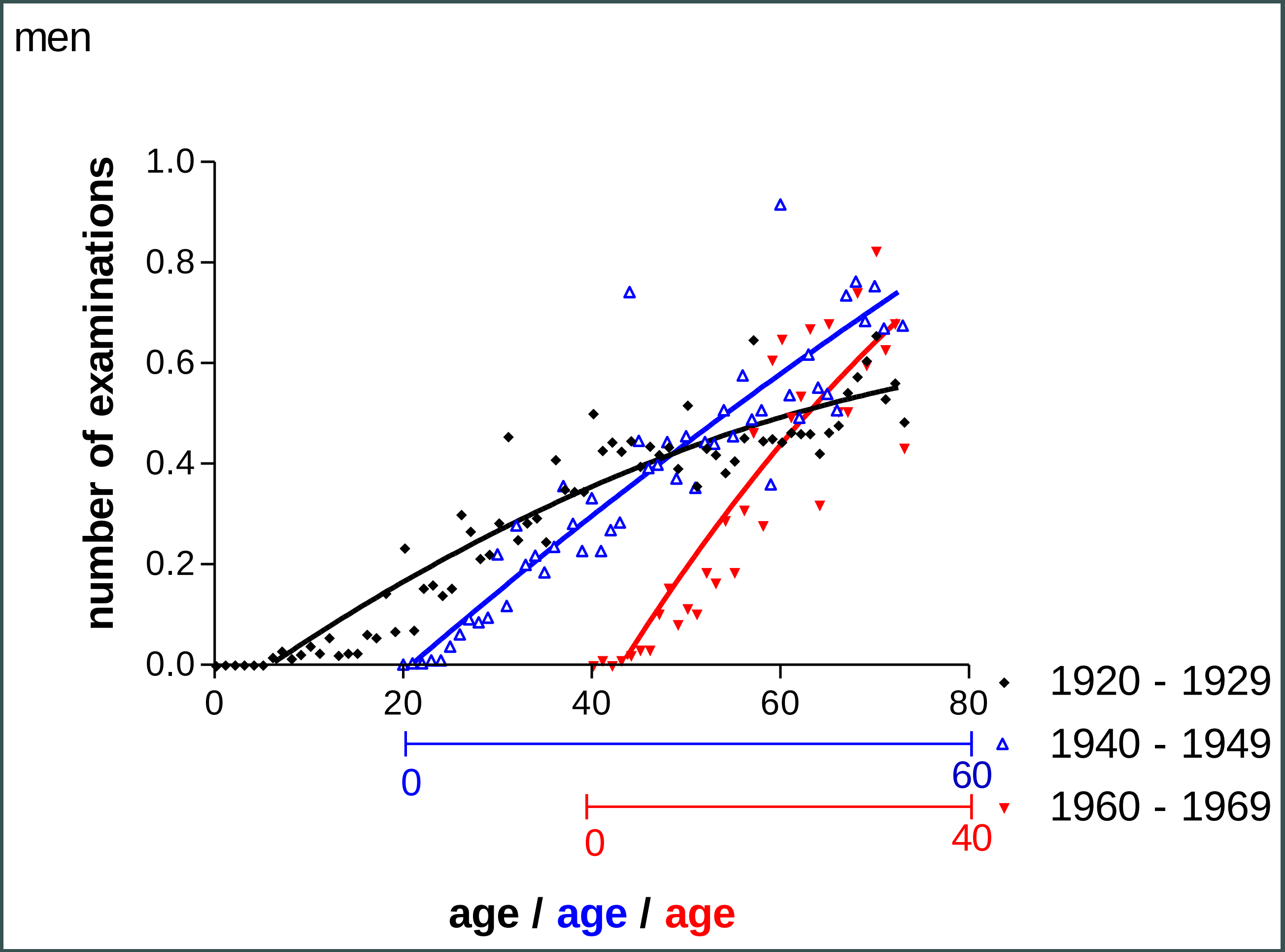
4. Results
Number of examinations
considering 3 cohorts of male subjects in the study



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Number of examinations
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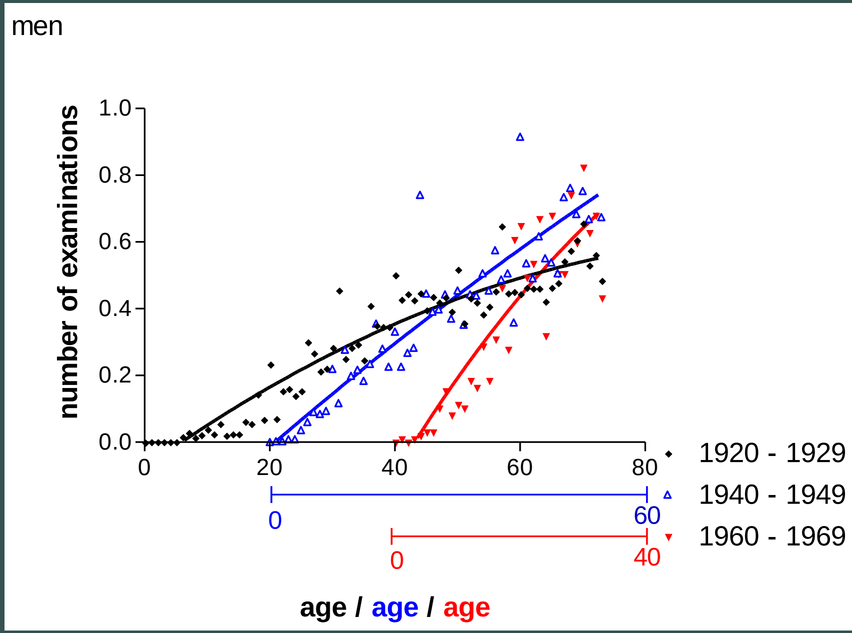

• The number of radiologic examinations for diagnostic purposes increases continuously over lifetime in all cohorts. The rise appears to be less steep in childhood and young adults and becomes steeper in later life.

• For adults the number of examinations is similar in all cohorts

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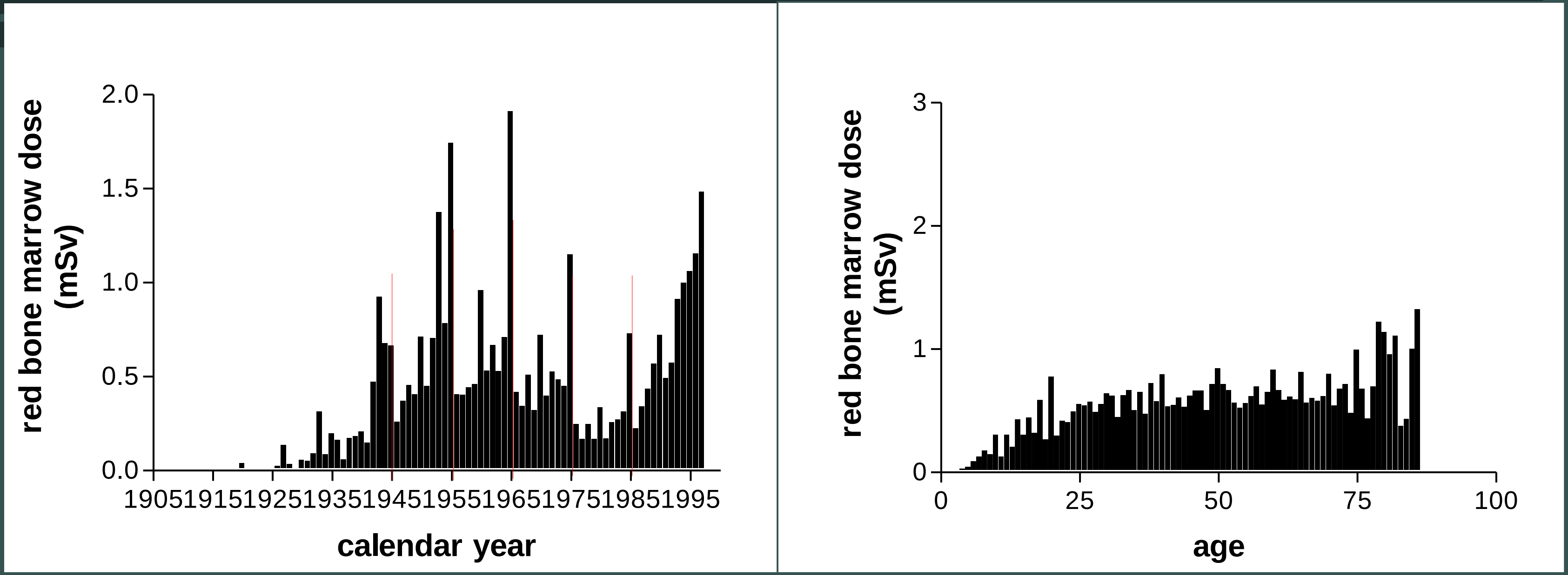
Mean values of red bone marrow dose per calender year and age considering all male subjects of the study



- The dose depends slightly on age but more so on calendar year.
- Until 1970 traditional examinations like conventional and mass screening examinations caused the main dose.
- They were replaced by technically advanced examinations mainly computer tomography and cardiac catheter.

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Results: Red bone marrow dose

Remarkably, the distribution of the red bone marrow dose over lifetime seems to depend

- more on availability and development of the technique of examination and the radiologic practice
- than on age of the patients.

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