European Society of Radiology

Imaging Referral Guidelines in Europe:
Now and the Future
EC Referral Guidelines Workshop

September 20–21, 2012, Vienna, AUSTRIA

Radiation dose issues and risk

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German Commission on Radiological Protection (SSK)
German Roentgen Society (DRG)

- **The human perception of risk is extremely dependent on the current situation**

- **Some people are sure that there is “good” radiation (terrestric/cosmic) and “bad” radiation (e.g. medical X-rays) (no chest X-ray but frequent flyer)**

- **Justification is a balance of two involved risks**

- **The reduction of disease related morbidity/mortality by X-ray exams should be significant higher than the radiation risk (our weakest point of evidence)**

- **The assessment of individual medical exposure without knowledge of clinical circumstances is not helpful**

- **A head-CT after trauma with 2 mSv is different for an 8 year child and an 80 year adult**

- **An abdomen-CT with 10 mSv is different for a 40 year old women with lumbar back pain and for the same patient with proven pancreatic cancer**

EUROPEAN COMMISSION

RADIATION PROTECTION 118

Update Mars 2008

Referral Guidelines For Imaging

Directorate-General for Energy and Transport
Directorate H — Nuclear Energy
Unit H.4 — Radiation Protection
2007

… about dose

SSK

Berichte der Strahlenschutzkommission (SSK)
des Bundesministeriums für Umwelt, Naturschutz und Reaktorsicherheit
Heft 51 (2006) (Update 2010)

Orientierungshilfe

für radiologische und nuklearmedizinische Untersuchungen

Empfehlung der Strahlenschutzkommission

H. HOFFMANN GmbH - FACHVERLAG, Berlin

EU (RP 118)

	mSv	# chest exams		# days nat. bg.
Radiographic examinations:				
Limbs and joints (except hip)	<0.01	<0.5		<1.5 days
Chest (single PA film)	0.02	1	120/a	3 days
Skull	0.06	3		9 days
Thoracic spine	0.7	35		4 months
Lumbar spine	1.0	50		5 months
Hip	0.4	20		2 months
Pelvis	0.7	35		4 months
Abdomen	0.7	35		4 months
IVU	2.4	120		14 months
Barium swallow	1.5	75		8 months
Barium meal	2.6	130		15 months
Barium follow through	3	150		16 months
Barium enema	7.2	360		3.2 years
CT head	2.0	100		10 months
CT chest	8	400		3.6 years
CT abdomen or pelvis	10	500		4.5 years
Radionuclide studies:				
Lung ventilation (Xe-133)	0.3	15		7 weeks
Lung perfusion (Tc-99m)	1	50		6 months
Kidney (Tc-99m)	1	50		6 months
Thyroid (Tc-99m)	1	50		6 months
Bone (Tc-99m)	4	200		1.8 years
Dynamic cardiac (Tc-99m)	6	300		2.7 years

Germany

Röntgenuntersuchungen:[2]	mSv
Extremitäten und Gelenke (außer Hüfte)	0,01
Thorax (einzelne p.a.-Aufnahme)	0,04
Thorax in 2 Ebenen	0,1
Schädel	0,07
Brustwirbelsäule	0,7
Lendenwirbelsäule	1,3
Hüfte	0,3
Becken	0,7
Abdomen	1,0
Mammographie bds. 2 Ebenen	0,5
Ausscheidungsurografie	2,5
Barium-Bolus	1,5
Bariumbrei	3
Bariumeinlauf	7
CT - Kopf	2,3
CT - Thorax	8
CT - Abdomen oder Becken	10
CT - Ganzkörper[3]	14
Nuklearmedizinische Untersuchungen:[4]	
Nierenfunktionsszintigraphie (100 MBq Tc-99m-MAG3)	0,7
Schilddrüsenszintigraphie (75 MBq Tc-99m)	1,0
Lungenperfusionsszintigraphie (100 MBq Tc-99m-Micropartikel)	1,1
Skelettszintigraphie (500 MBq Tc-99m-Phosphonat)	2,9
Hirnszintigraphie (550 MBq Tc-99m-HMPAO o.ä.)	5,1
Myocardperfusionsszintigraphie (600 MBq Tc-99m-MIBI)[5]	5,4

Table B45a. Mean patient dose[a] for various medical and dental radiological examinations
Data from the UNSCEAR Global Survey of Medical Radiation Usage and Exposures

Health-care level	*Country*	*Chest*		
		Chest PA	*Chest LAT*	
I	Australia	0.16	0.73	
	Belgium	0.15	1.23	1:8.2
	Czech Republic	0.40	1.20	
	Germany	**0.13**	0.46	PA 20% of Norway
	Greece	0.50		
	Hungary	0.52	0.91	
	Iceland	**0.57**		
	Japan	0.33	0.44	
	Lithuania	0.44	1.60	
	Malta	0.20	0.45	
	Netherlands	0.04		
	Norway	**0.64**	**0.82**	DAP 1:1.3
	Romania	1.30	3.50	
	Slovenia	0.29	0.96	
	Spain	0.17	0.49	
	Sweden ???	**0.40**	**0.40**	
	Switzerland	0.10	0.20	1:2.0
	United Kingdom	0.16		
II	Chile	0.20	0.70	
	Mauritius	0.40	1.50	
	Oman	0.44		
	Thailand	0.20		
	Tunisia	0.20		
	Turkey	0.38		

[a] Values in regular type are for entrance air kerma in mGy; values in bold type are for DAP in Gy cm².

SOURCES AND EFFECTS OF IONIZING RADIATION

United Nations Scientific Committee on the Effects of Atomic Radiation

UNSCEAR 2008
Report to the General Assembly
with Scientific Annexes

VOLUME I

UNITED NATIONS
New York, 2010

How reliable are our data ?

- Questionnaires ?
- Health insurance companies ?
- National reporting systems ?

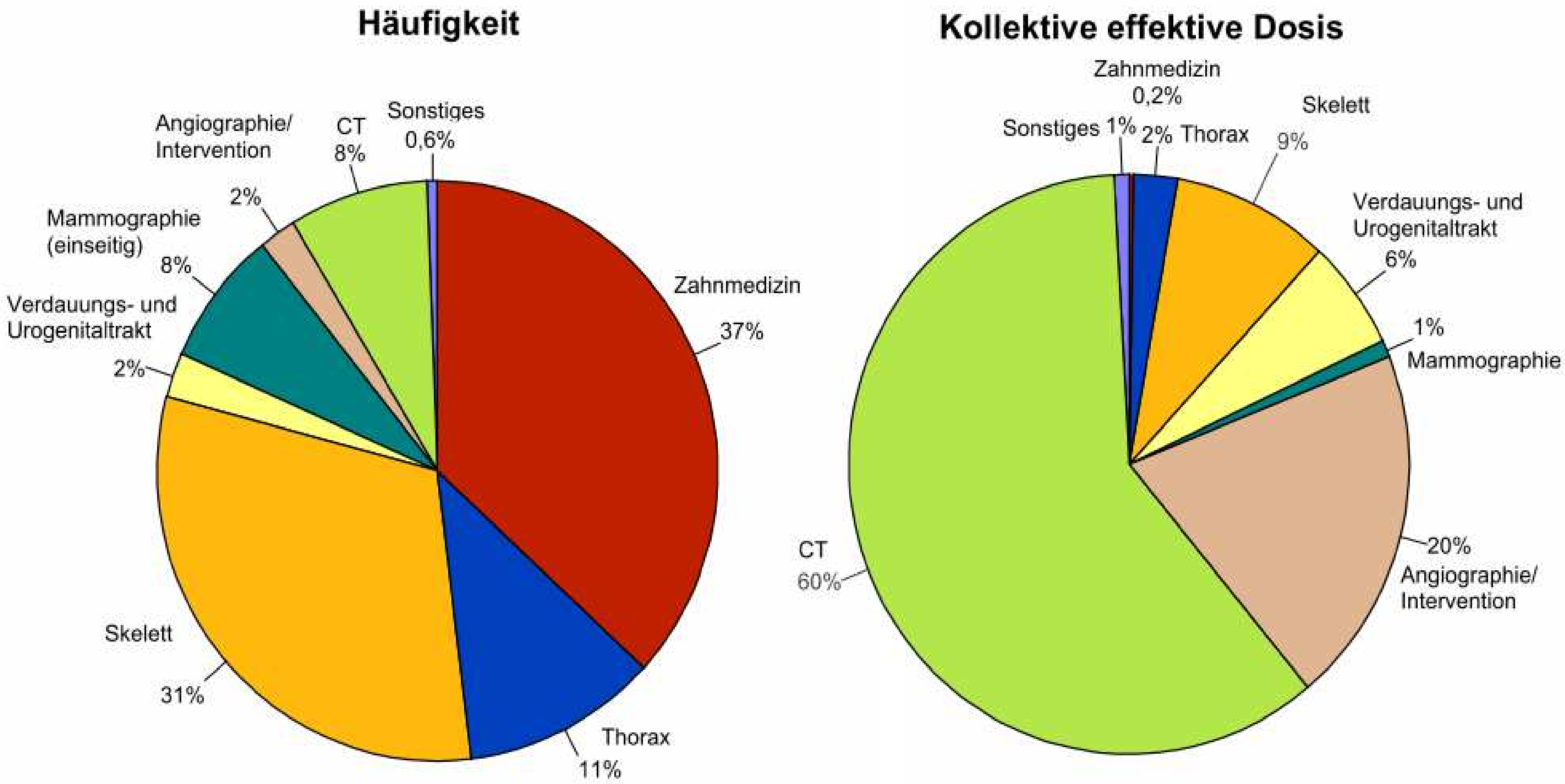
Table B43a. Annual number of various medical examinations per 1,000 population
Data from the UNSCEAR Global Survey of Medical Radiation Usage and Exposures

Health-care level	Country	Chest			
		Chest PA	Chest LAT	Photo-fluorography	Fluoroscopy
CR/ DR	Australia	108.21	71.76		
	Austria	241.1	146.34		
	Belgium	246.00	159.00	0.04	
	Bulgaria	69.85	29.93	11.55	4.14
	Croatia	152.54	85.34		7.30
	Czech Republic	103.02	5.65	0.00	4.23
	Finland	223.60			
	France	90.76			
	Germany	207.69			
	Greece	309.09			
	Hungary	480.31	46.39	30.16	55.10
	Iceland	163.24			
	Japan	653.44			3.12
	Korea, Rep.	391.60	45.21		
I	Latvia	202.35		139.52	
	Lithuania	126.17		327.13	48.91
	Luxembourg	118.17	47.39		
	Malta	82.63	1.44		
	Netherlands	166.26			
	Norway ???	39.93	117.47		
	Romania	45.93	14.47	63.80	90.40
	Russian Federation	71.57	58.21	406.95	17.72
	Slovenia	193.71	60.41		
	Spain	326.26	146.48		
	Sweden ???	94.91	94.91		
	Switzerland	187.64	46.91	6.84	0.43
	The former Yugoslav Republic of Macedonia	2.12			
	United Kingdom	139.50			
	Weighted average	168	70	287	17

Table B43c. Annual number of various medical examinations per
Data from the UNSCEAR Global Survey of Medical Radiation Usage and Exp

Health-care level	Country	Head	Thorax	Abdomen
CT	Australia			
	Austria	26.59	12.32	11.71
	Belgium	42.00	65.00	65.00
	Bulgaria			
	Croatia	20.16	0.00	0.00
	Czech Republic	18.21	4.35	7.59
	Finland	26.00	6.30	11.99
	France	30.79	10.05	15.07
	Germany	39.61	18.04	27.51
	Greece	19.09	16.36	18.18
	Hungary	27.65	19.94	22.54
	Iceland	36.46	9.99	20.49
	Japan	130.36	87.63	101.06
I	Korea, Rep.	18.74	4.02	5.92
	Latvia	27.23	8.71	12.55
	Lithuania			
	Luxembourg	43.79	13.35	26.28
	Malta	14.18	3.38	6.77
	Netherlands	19.18	13.43	19.50
	Norway	39.64	10.70	17.52
	Romania	10.86	10.38	
	Russian Federation	4.87	0.70	1.39
	Slovenia	14.98	14.98	14.98
	Spain	16.31	5.60	14.63
	Sweden	36.56	10.95	14.45
	Switzerland	26.27	11.26	22.25
	United Kingdom	10.39	3.24	4.99
	Weighted average	40	24	30

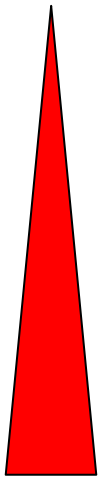
Prozentualer Anteil der verschiedenen Untersuchungsarten an der Gesamthäufigkeit und an der kollektiven effektiven Dosis in Deutschland für das Jahr 2009



Report to the German parliament 2010 on medical exposure

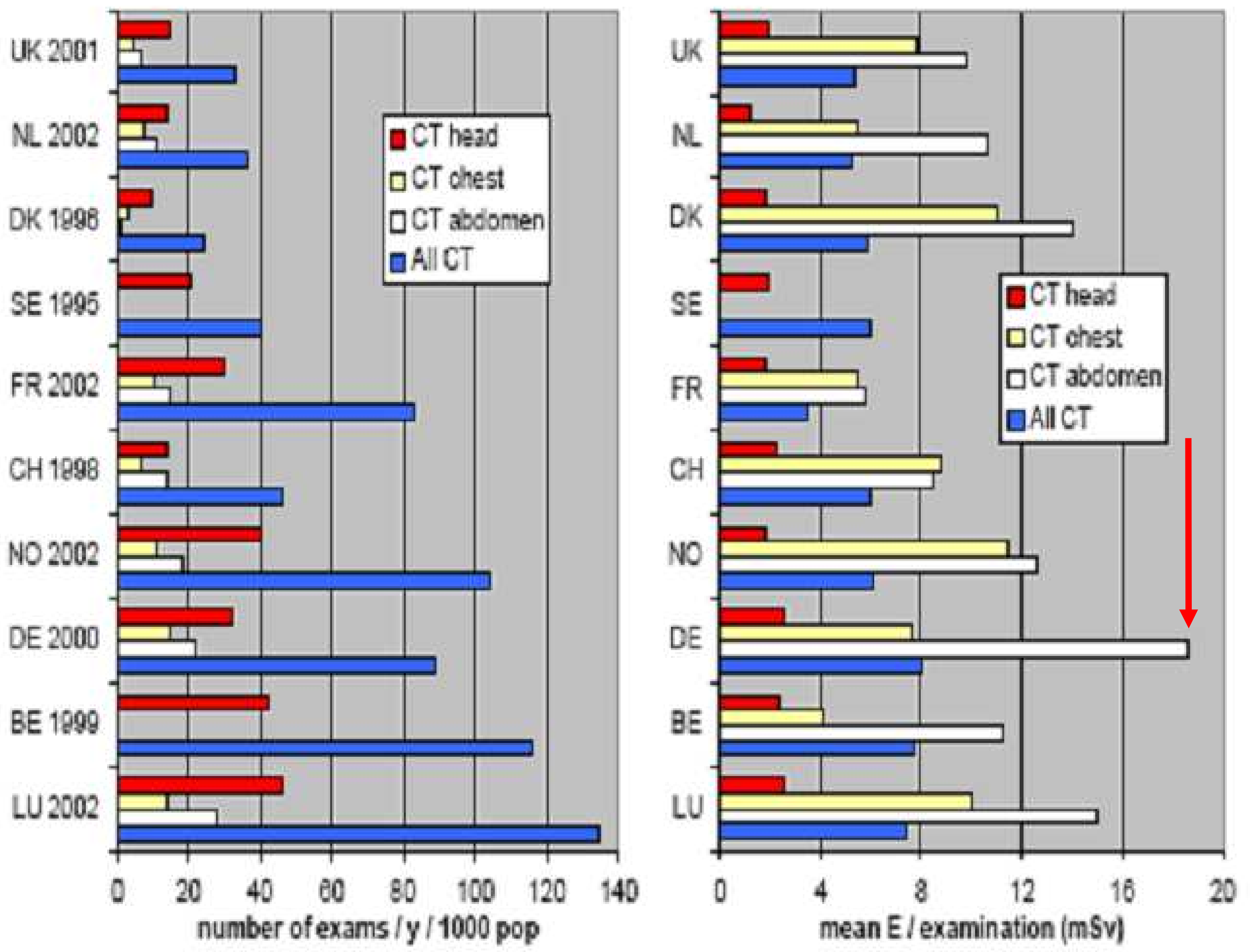
Table 2 Band Classification of the typical effective doses of ionising radiation from common imaging procedures

Band	Typical effective dose (mSv)	Examples
0	0	US, MRI
I	<1	CXR, XR limb, XR pelvis
II*	1-5	IVU, XR lumbar spine, NM (e.g. skeletal scintigram), CT head & neck
III	5-10	CT chest and abdomen, NM (e.g. cardiac)
IV	>10	Some NM studies (e.g. some PET)



* *The average annual background dose in most parts of Europe falls in band II.*

Comparison of frequency/1000, dose/exam and collective effective dose for different type of CT-examinations



Communication of benefit and risk to the referring physician or patient

“which bridge would you prefer to cross ?”

Medical procedure
with X-rays ?

Medical procedure
without X-rays ?

On Fates Comparable to Death

Ronald A. Howard
Management Science
Vol. 30, No. 4, Risk Analysis (Apr., 1984), pp. 407-422
Published by: INFORMS
Article Stable URL: http://www.jstor.org/stable/2631429

A **micromort** is a unit of risk measuring a one-in-a-million probability of death (from micro- and mortality). Micromorts can be used to measure riskiness of various day-to-day activities. A **microprobability** is a one-in-a million chance of some event; thus a micromort is the microprobability of death. The micromort concept was introduced by Ronald A. Howard who pioneered the modern practice of decision analysis.

Activities that increase the death risk by one micromort, and their associated cause of death:

- Smoking 1.4 cigarettes (cancer, heart disease)[5]
- Drinking 0.5 liter of wine (cirrhosis of the liver)[5]
- Living 2 days in New York or Boston (air pollution)[5]
- Living 2 months in Denver (cancer from cosmic radiation)[5]
- Drinking Miami water for 1 year (cancer from chloroform)[5]
- Eating 100 charcoal-broiled steaks (cancer from benzopyrene)[5]
- Eating 40 tablespoons of peanut butter (liver cancer from Aflatoxin B)[5]
- Eating 1000 bananas, (cancer from radioactive 1 k**BED** of Potassium-40)
- Travelling 6 miles by motorbike (accident)[6]
- Travelling 17 miles by walking (accident)[7]
- Travelling 230 miles (370 km) by car (accident)[6] (or 250 miles[7])
- Flying 1000 miles (1609 km) by jet (accident)[5]
- Flying 6000 miles (9656 km) by jet (cancer from cosmic radiation)[5]
- Receiving one 10mrem **(0.1 mSv)** chest X-ray in a good hospital (cancer from radiation)[8]
- **Being 63 years old for 38 minutes (male, Germany, 2010)**

Increase in death risk for other activities on a per event basis:

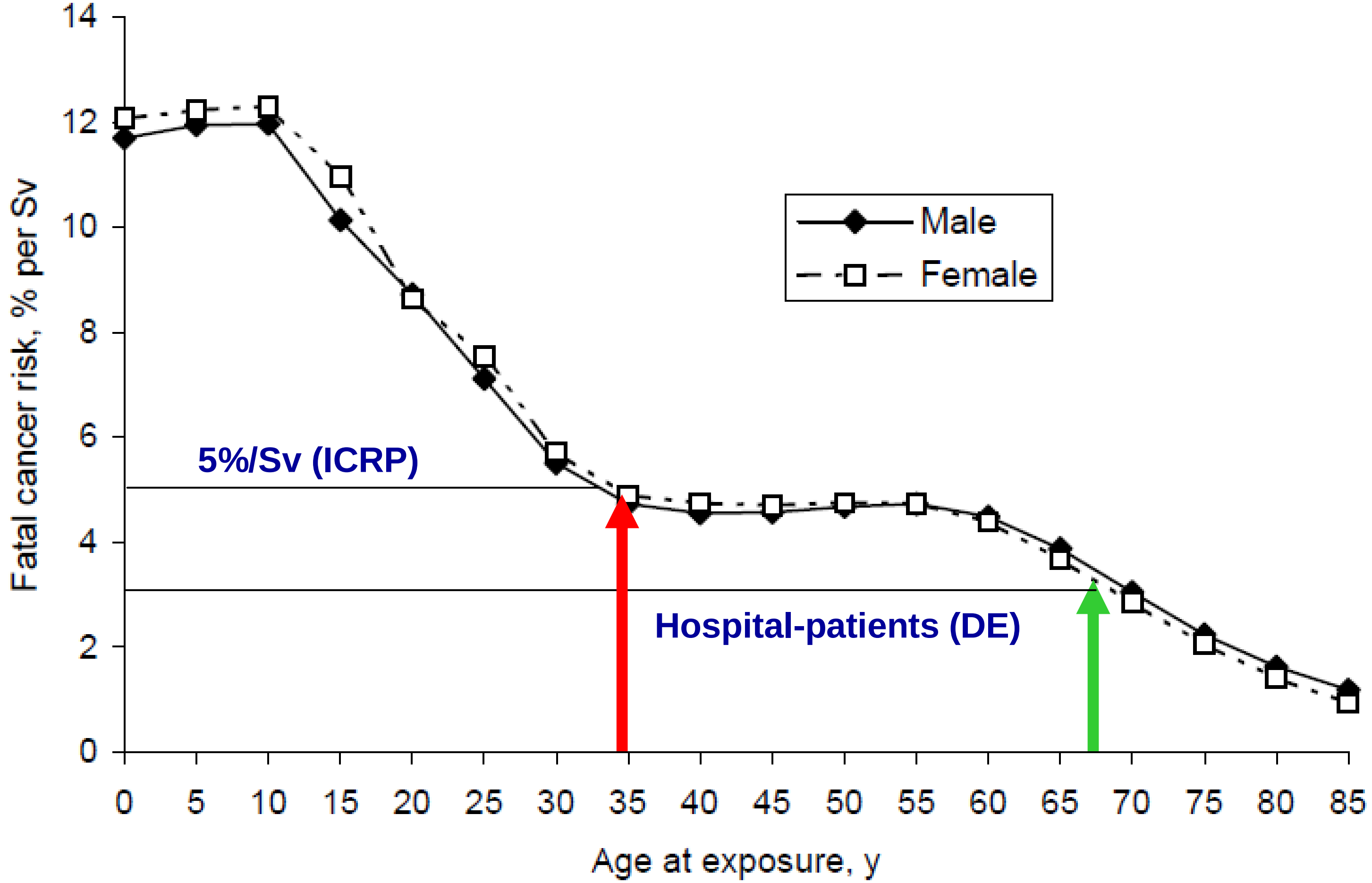
Hang gliding – 8 micromorts per trip[6]
Scuba diving – 4.72 micromorts per dive[9]
Skydiving (in the US) – 7 micromorts per jump[10]

http://en.wikipedia.org/wiki/Micromort

Radiographic examinations: mSv	
Limbs and joints (except hip)	<0.01
Chest (single PA film)	0.02
Skull	0.06
Thoracic spine	0.7
Lumbar spine	1.0
Hip	0.4
Pelvis	0.7
Abdomen	0.7
IVU	2.4
Barium swallow	1.5
Barium meal	2.6
Barium follow through	3
Barium enema	7.2
CT head	2.0
CT chest	8
CT abdomen or pelvis	10
Radionuclide studies:	
Lung ventilation (Xe-133)	0.3
Lung perfusion (Tc-99m)	1
Kidney (Tc-99m)	1
Thyroid (Tc-99m)	1
Bone (Tc-99m)	4
Dynamic cardiac (Tc-99m)	6
PET head (F-18 FDG)	5

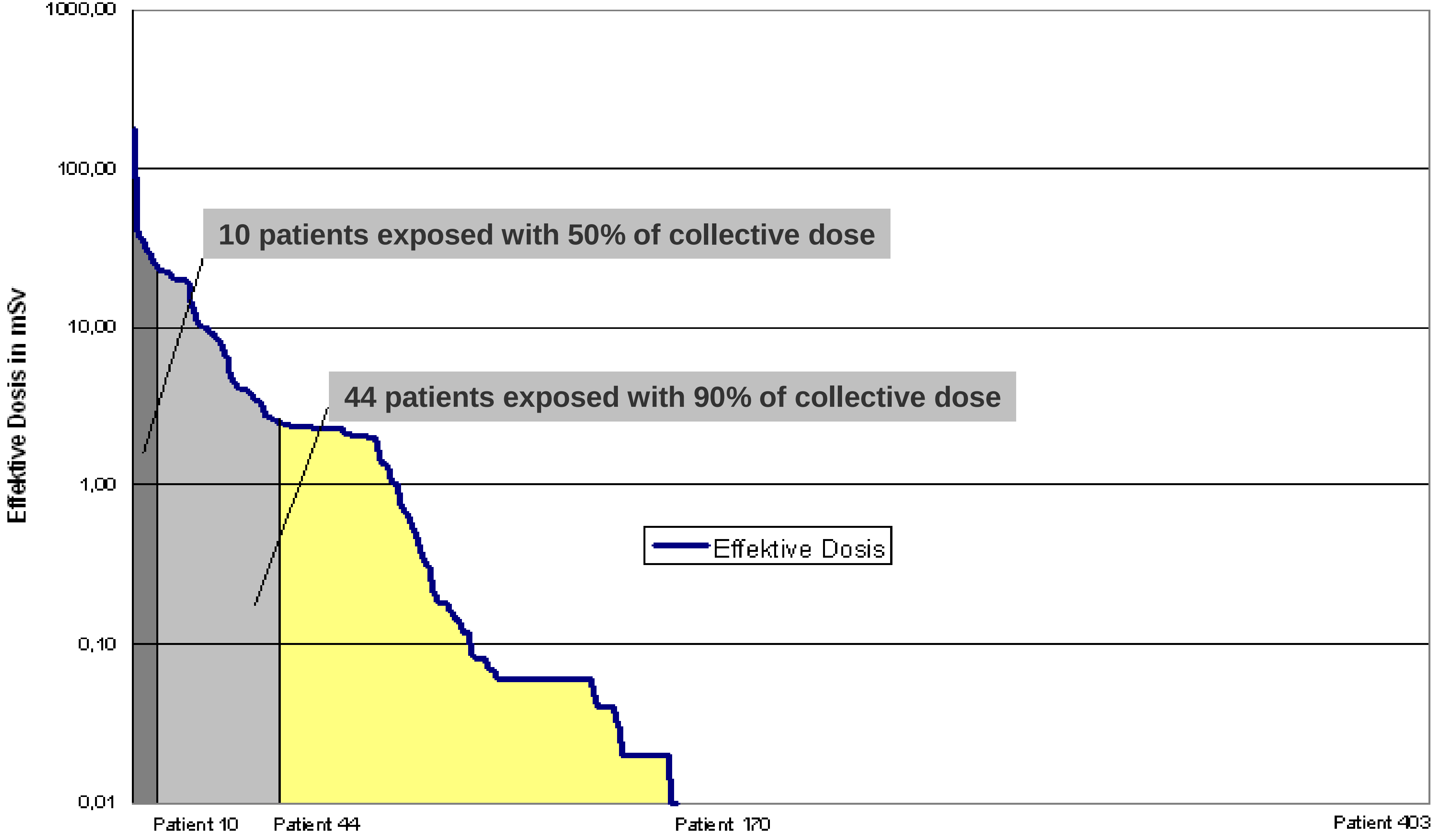
1 micromort (1 chest X-ray)
Smoking 1.4 cigarettes (cancer, heart disease)
Living 2 days in New York or Boston (air pollution)
Travelling 370 km by car (accident)
1 flight (1000 miles) by jet (accident)

100 micromorts (1 abdomen CT)
Smoking 10 packs of cigarettes (cancer, heart disease)
Living 6.5 month in New York or Boston (air pollution)
Travelling 37.000 km = 2-3 years by car (accident)
100 flights (1000 miles) by jet (accident)
Working as stewardess for 3 years (air crew)
~ 3 mSv/a
Being 63 years old for 2.6 days (male, Germany, 2010)



Total excess fatal cancer risk for uniform whole body exposure as a function of age at exposure and sex (Wall, 2004)

Hospital Nuremberg, Germany, 2.400 patient beds



Distribution of collective dose of 873 mSv onto 403 patients

Patient	effective dose (mSv)	Age/Sex	Main-diagnosis	2nd-diagnosis	
1	177,61	79 y, male	C25.0	J44.8	Pancreatic cancer
2	44,49	74 y, female	C78.7	D64.8	Liver metastasis
3	36,68	57 y, male	T82.7	E66.0	Infection of heart valve
4	36	56 y, male	J18.0	B16.9	Severe pneumonia
5	30,18	70 y, male	C78.7	C78.8	Liver metastasis
6	28	82 y, female	R19.0	C77.1	Pelvic malignant lymphoma
7	25,63	75 y, female	I10	D64.9	Hypertension (cardiology)
8	25,41	61 y, male	I25.10	E11.40	Coronary artery sclerosis
9	22,89	69 y, male	K50.1	D12.4	Crohns disease
10	22,43	89 y, male	I74.7	I10	Pulmonary embolism
		mean age 71.2 y			

Take home points

•The risk of medical exposure is in the range of various day-to-day activities

•Assessment of dose alone is not helpful

•No justification without knowledge of clinical circumstances

•Dose should be minimized in occupational exposure but not in medicine
(optimization = ALARA)

•What is the appropriate amount of dose ?
(avoid non justified exams but also provide justified exams, shift of risks)

•Think about the wording "guidelines" (risk of misuse)
(criteria, appropriateness? MBUR? Orientierungshilfe? DIP?)

•Risk of medical imaging is not calculating radiation death with
5%/Sv from ICRP

The risk of medical imaging with good practice and justification is far away from death, but …

Death is not the worst evil, but rather when we wish to die and cannot. *Sophocles (c. 496 B.C.–406 B.C.)*

Thank you