Docente: Marie Claire Cantone

Lezione 1, 2, 3

Argomenti

- Commissione Internazionale di Protezione Radiologica
- Scopo delle Raccomandazioni ICRP
- Struttura concettuale della RP
- Sistema di protezione radiologica per pratiche e interventi (ICRP 60)
- Concetto di detrimento
- I tre tipi di esposizione: occupazionale, medica, della popolazione
- Esposizioni potenziali
- Cenni questioni etiche in RP

- **Rischio radiologico:**

  -le basi per giudicare la significatività degli effetti delle radiazioni e modelli di proiezione (annex C ICRP60)
  -il giudizio degli esperti e la percezione del rischio
  -punti chiave della comunicazione del rischio

- **Evoluzione del sistema di protezione radiologica verso le nuove raccomandazioni**

  -analisi Raccomandazioni ICRP 103
  -documenti a supporto di ICRP 103
  -punti significativi della revisione

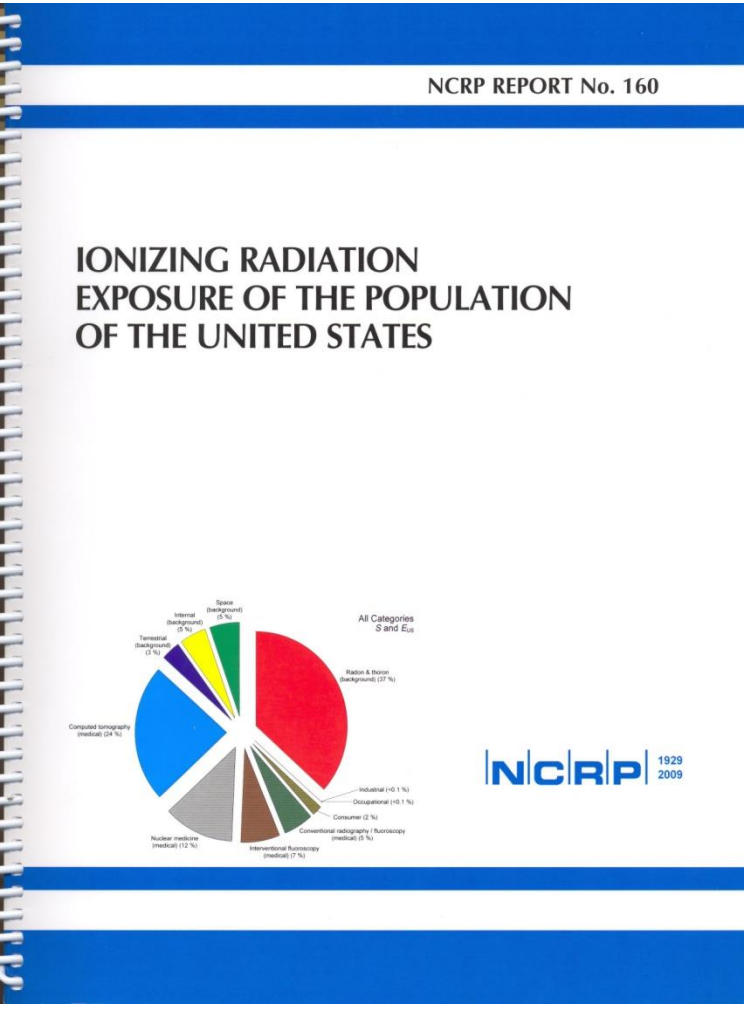
- **Il problema della stima di rischio nella diagnostica per immagine**

Il problema della stima di rischio nella diagnostica per immagine

NCRP Report No. 160 – 2009

Ionizing Radiation Exposure of the Population on the United States

(aggiornamenti di analogo report del 1987)

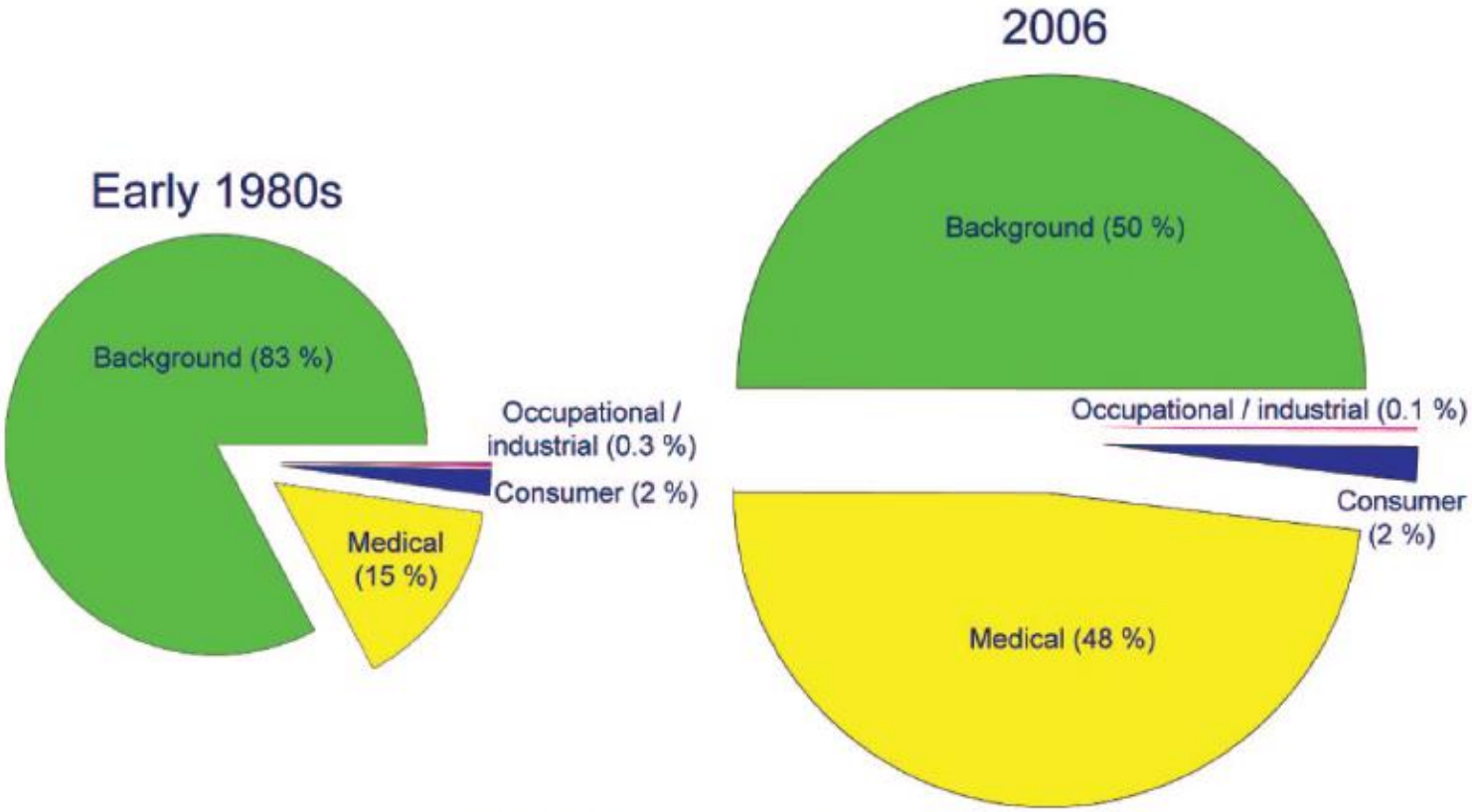


- **Dai primi anni 80 vi è stato un incremento di oltre 6 volte nella esposizione della popolazione <u>per procedure mediche</u>.**

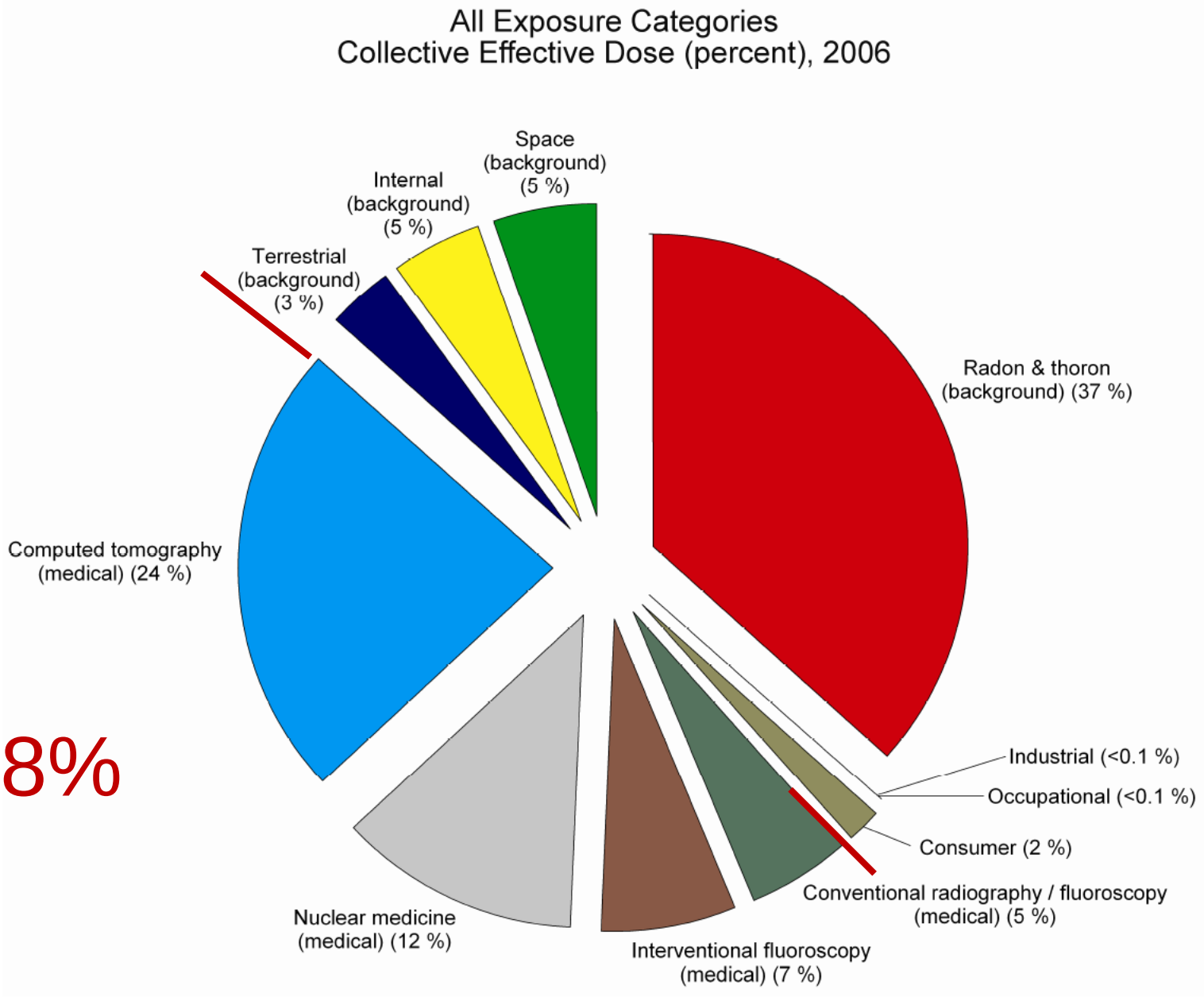
- **L'esposizione per procedure mediche rappresenta circa il <u>50% della totale esposizione dalle diverse categorie</u> in termini di percentuale di dose efficace per individuo.**

Health Physics July 2009, Volume 97, Number 1

NCRP Report No. 160, *Ionizing Radiation Exposure of the Population of the United States*



	Early 1980s	2006
Collective effective dose (person-Sv)	835,000	1,870,000
Effective dose per individual in the U.S. population (mSv)	3.6	6.2

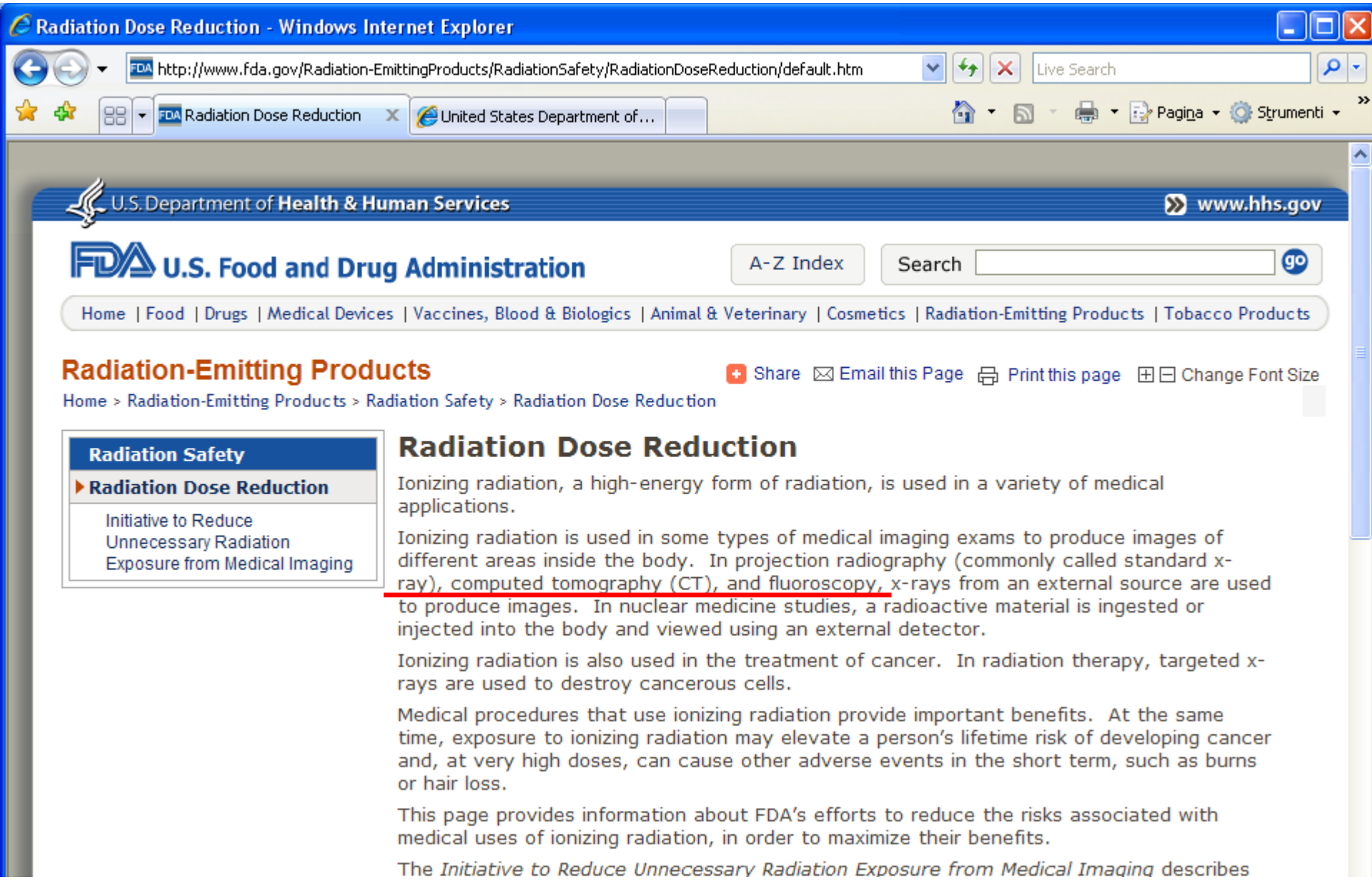

All Exposure Categories
Collective Effective Dose (percent), 2006
Space (background) (5 %)
Internal (background) (5 %)
Terrestrial (background) (3 %)
Radon & thoron (background) (37 %)
Computed tomography (medical) (24 %)
Industrial (<0.1 %)
Occupational (<0.1 %)
Consumer (2 %)
Conventional radiography / fluoroscopy (medical) (5 %)
Nuclear medicine (medical) (12 %)
Interventional fluoroscopy (medical) (7 %)

48%

PROCEDURE	Effective dose per individual 1980s (mSv)	Effective dose per individual 2006 (mSv)
CT	0.016	1.47
Radiography, fluoroscopy	0.36	0.33
Interventional fluoroscopy	0.018	0.43
Nuclear medicine	0.14	0.77
TOTAL	0.53	3.00

"Ionizing Radiation Exposure of the Population of the United States," March 3, 2009.

Data does not include radiation dose from radiation therapy, PET/CT, SPECT/CT, CT/fluoroscopy, and interventional applications


Radiation Dose Reduction - Windows Internet Explorer
http://www.fda.gov/Radiation-EmittingProducts/RadiationSafety/RadiationDoseReduction/default.htm
Live Search
Radiation Dose Reduction
United States Department of...
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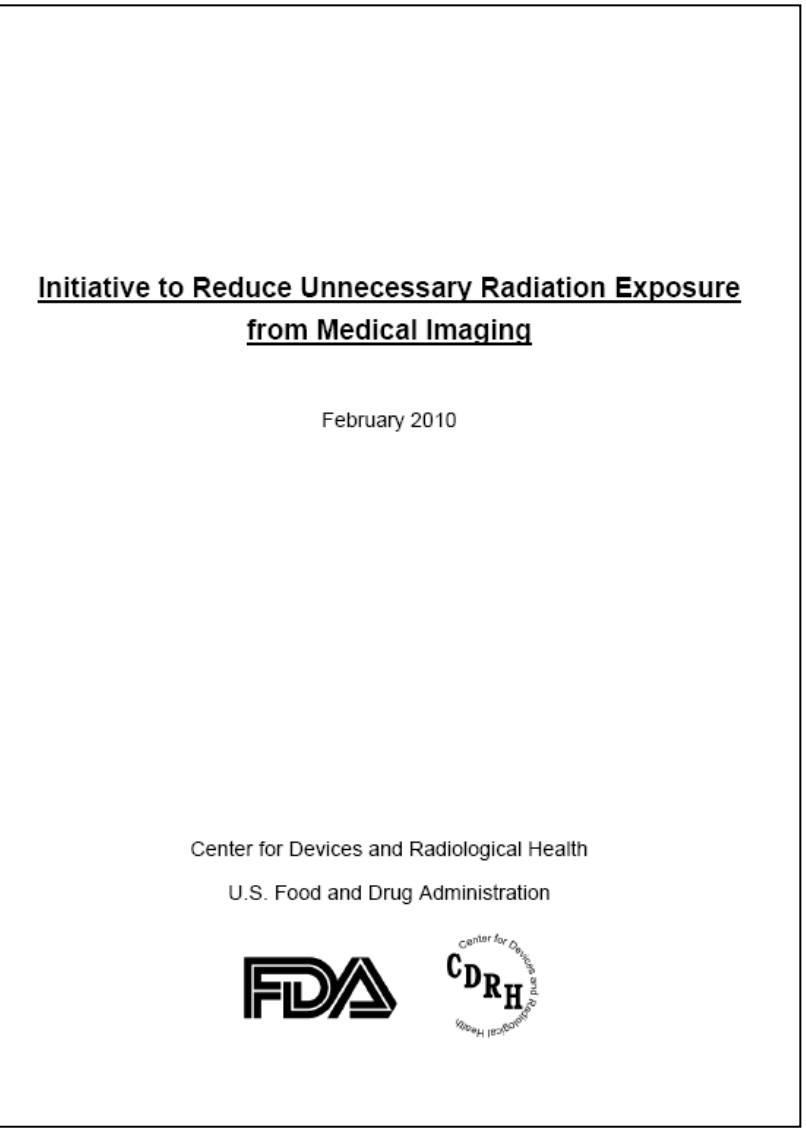
Radiation Safety
Radiation Dose Reduction
Initiative to Reduce Unnecessary Radiation Exposure from Medical Imaging
Radiation Dose Reduction
Ionizing radiation, a high-energy form of radiation, is used in a variety of medical applications.
Ionizing radiation is used in some types of medical imaging exams to produce images of different areas inside the body. In projection radiography (commonly called standard x-ray), computed tomography (CT), and fluoroscopy, x-rays from an external source are used to produce images. In nuclear medicine studies, a radioactive material is ingested or injected into the body and viewed using an external detector.
Ionizing radiation is also used in the treatment of cancer. In radiation therapy, targeted x-rays are used to destroy cancerous cells.
Medical procedures that use ionizing radiation provide important benefits. At the same time, exposure to ionizing radiation may elevate a person's lifetime risk of developing cancer and, at very high doses, can cause other adverse events in the short term, such as burns or hair loss.
This page provides information about FDA's efforts to reduce the risks associated with medical uses of ionizing radiation, in order to maximize their benefits.
The Initiative to Reduce Unnecessary Radiation Exposure from Medical Imaging describes

FDA, Feb. 2010


Initiative to Reduce Unnecessary Radiation Exposure from Medical Imaging

February 2010

Center for Devices and Radiological Health

U.S. Food and Drug Administration

FDA

CDRH

"Like all medical procedures, computed tomography (CT), fluoroscopy, and nuclear medicine imaging exams present both benefits and risks.

These types of imaging procedures have led to improvements in the diagnosis and treatment of numerous medical conditions.

At the same time, these types of exams expose patients to ionizing radiation, which may elevate a person's lifetime risk of developing cancer.

A balanced public health approach seeks to support the benefits of these medical imaging exams while minimizing the risks. "

FDA, Feb. 2010

" …approximately 29 000 future cancers could be related to CT scans performed in the US in 2007. "

The largest contributions were from scans of the abdomen and pelvis (n = 14 000), chest (n = 4100) and head (n = 4000), as well as from chest CT angiography (n = 2700). One-third of the projected cancers were due to scans performed at the ages of 35 to 54 years compared with 15% due to scans performed at ages younger than 18 years,

Berrington de González A, et al. Arch. Internal Med., Dec. 2009

" estimate that 1 in 270 women and 1 in 600 men who undergo CT coronary angiography at age 40 will develop cancer from that CT scan ."

…. 1 in 8100 women who had a routine head CT scan at the same age (1 in 11 080 men). For 20-year-old patients, the risks were approximately doubled, and for 60-year-old patients, they were approximately 50% lower.

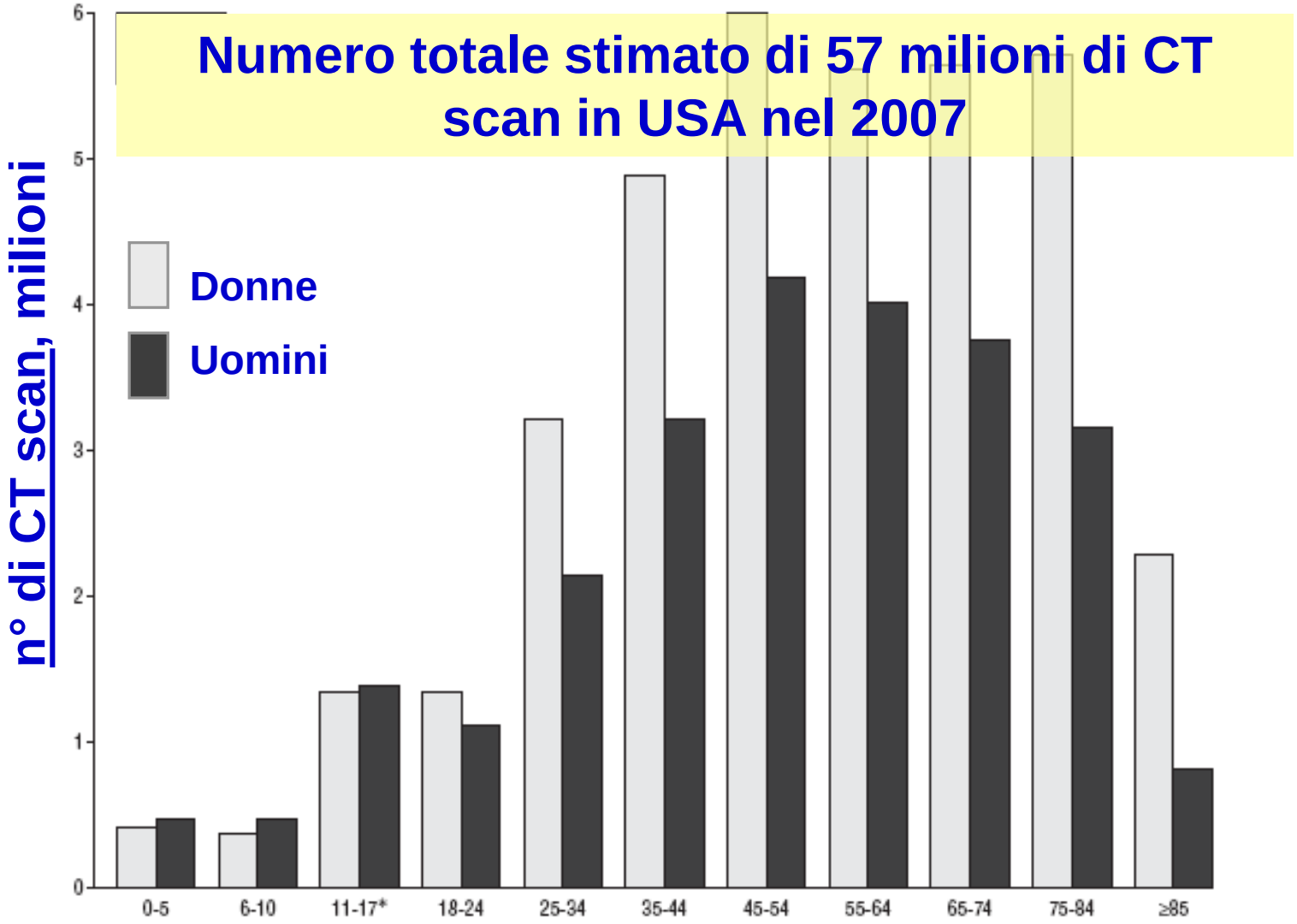
Smith-Bindman R, et al., Arch. Internal Med, Dec. 2009

"Projected Cancer Risks from Computed Tomographic Scans Performed in the United States in 2007"

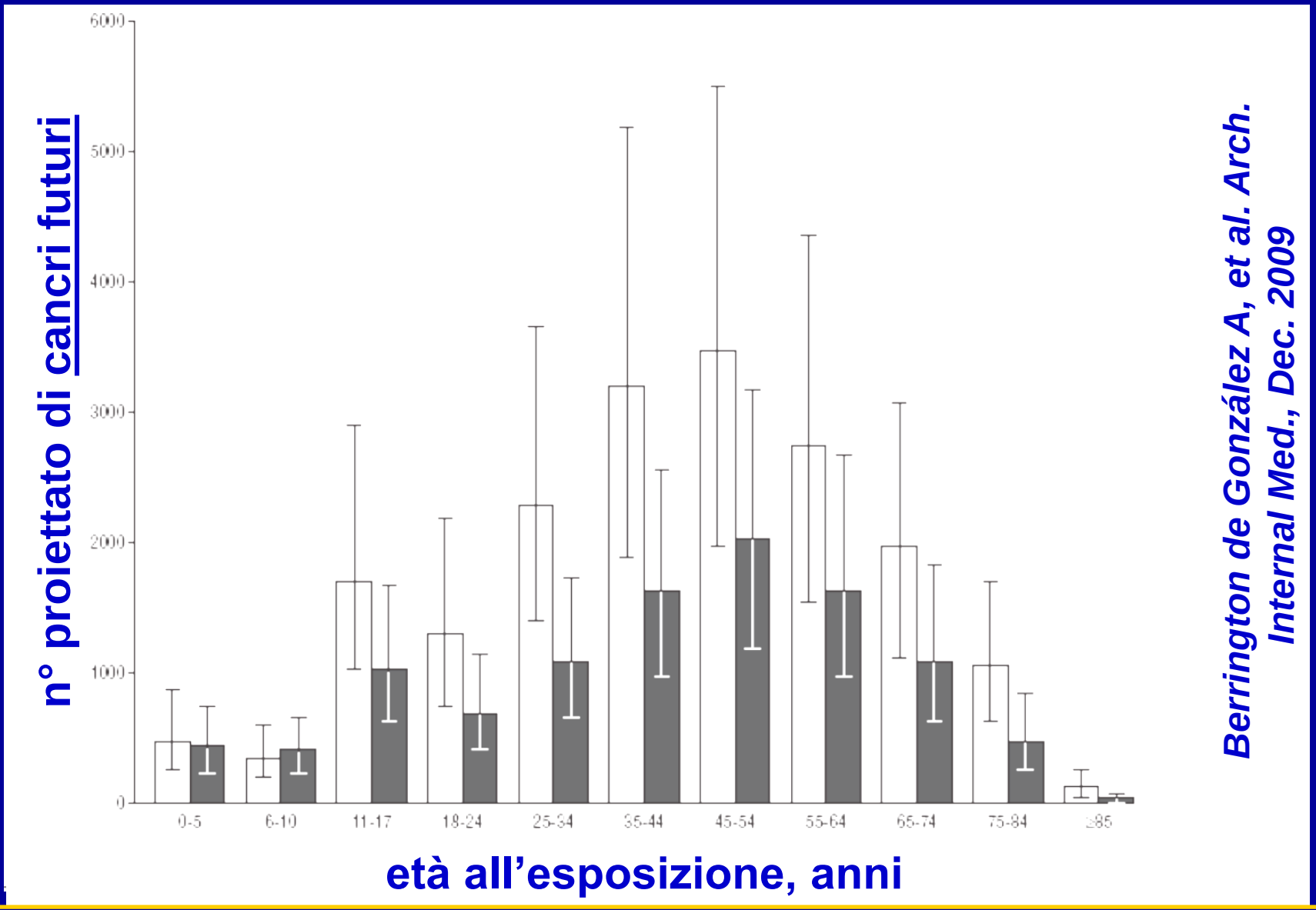
(Berrington de González A, et al. Arch. Internal Med., Dec. 2009)

- *usa database nazionali USA per stima il numero di CT per ogni tipologia e esclude la porzione di CT su pazienti ai loro ultimi 5 anni di vita (~ 11%) e su quelli con già diagnosi di cancro (~ 9%).*
- *usa tabelle FDA, 2007, e altre referenze per dare le dosi specifiche per organo per età, per sesso e per tipo di scan. (media delle dosi su diversi modelli di scanner). Le dosi ottenute sono molto simili a NCRP Report 160.*
- *usa modello di rischio BEIR VII, 2006.*
- *calcola il rischio con Monte Carlo tenendo conto incertezze su parametri di rischio, su DDREF, su trasporto di rischio da popolazione giapponese a statunitense.*

Numero di CT stimato in USA nel 2007 per sesso ed età all'esposizione.



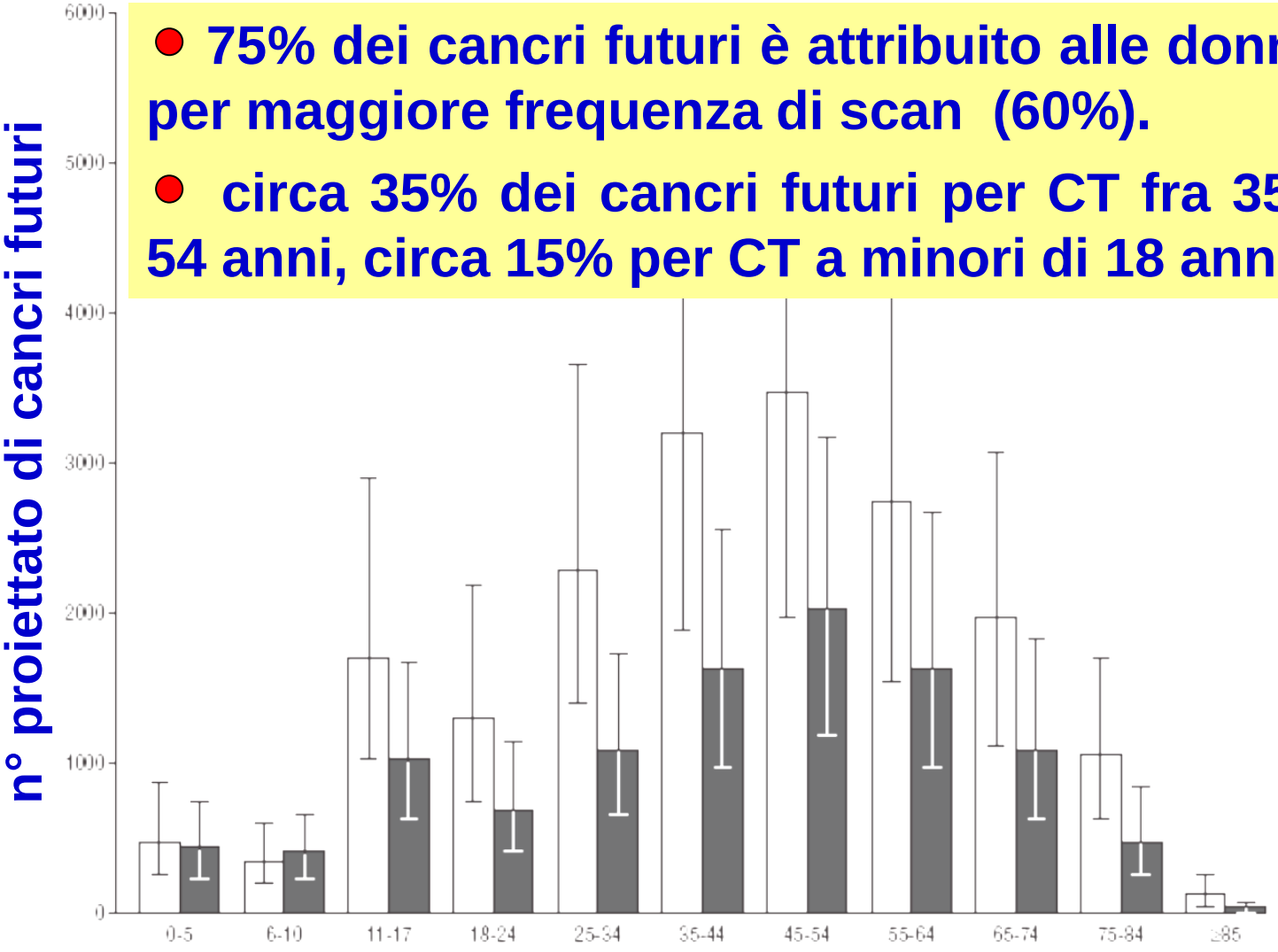
Numero proiettato di cancri futuri correlati alle CT in USA nel 2007 per sesso ed età all'esposizione.



Berrington de González A, et al. Arch. Internal Med., Dec. 2009

Numero proiettato di cancri futuri correlati alle CT in USA nel 2007 per sesso ed età all'esposizione.

- **75% dei cancri futuri è attribuito alle donne, per maggiore frequenza di scan (60%).**
- **circa 35% dei cancri futuri per CT fra 35 e 54 anni, circa 15% per CT a minori di 18 anni.**

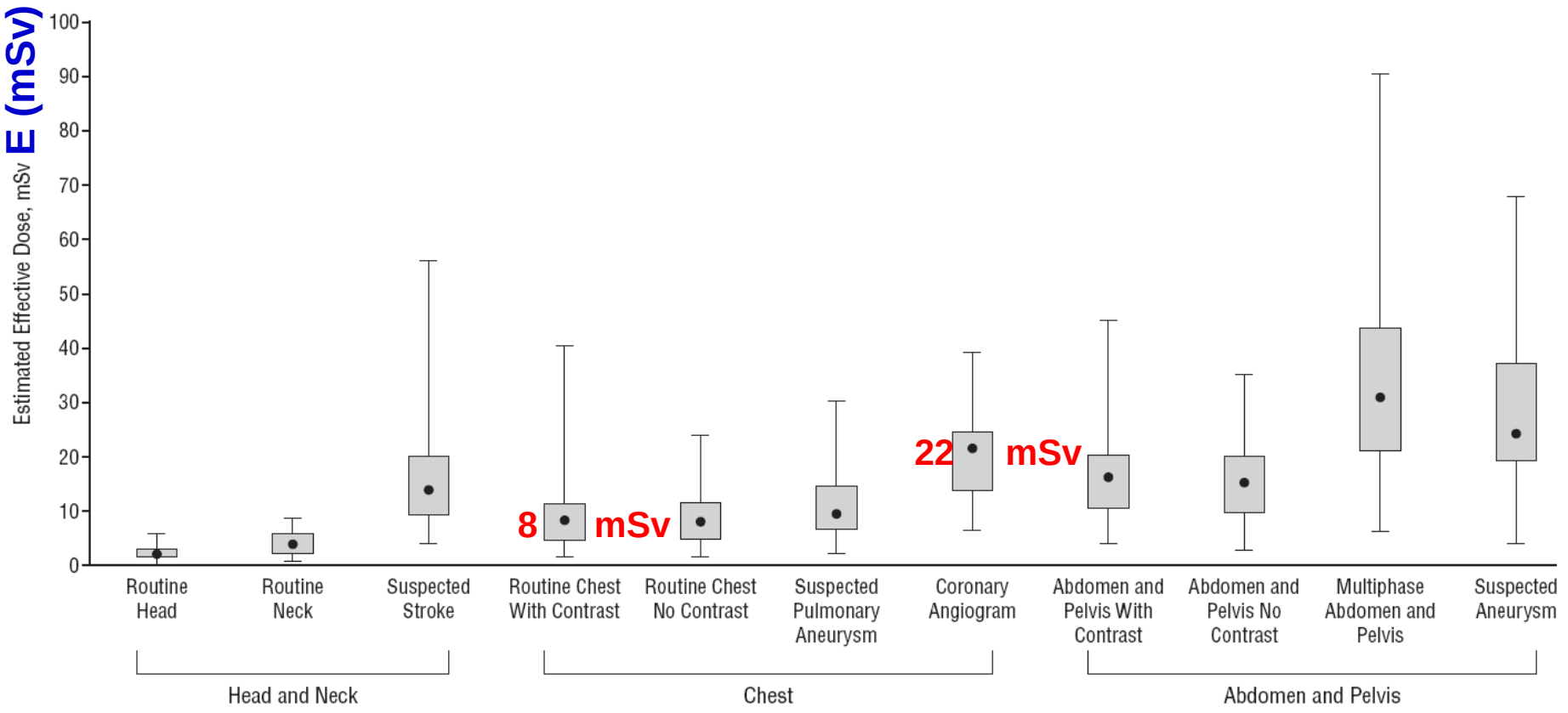


Berrington de González A, et al. Arch. Internal Med., Dec. 2009

Numero totale stimato di cancri futuri correlati ai 57 milioni di CT scan in USA nel 2007 è 29 000 (95% UL 15 000 – 45 000)

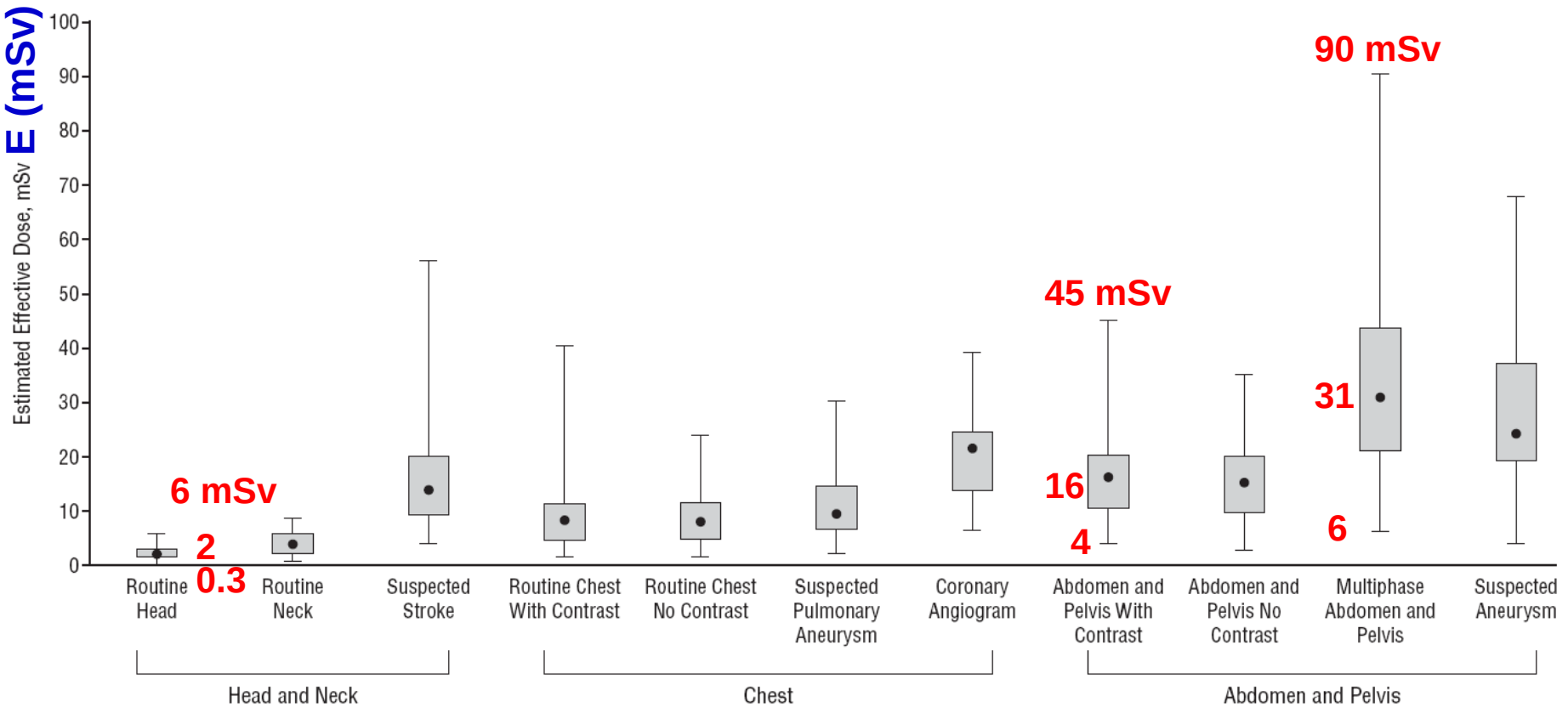
Tipo di CT	n° scan (%)	donne n° cancri (95% UL)	totale
Testa	$18.7 \cdot 10^6$ (33)	1900 (500 – 4400)	4000 (1100 – 8700)
Torace	$7.1 \cdot 10^6$ (12)	3100 (1400 – 6100)	4100 (1900 – 8100)
Abdom/pelvi	$18.3 \cdot 10^6$ (32)	8500 (4200 – 15000)	14000 (6900–25000)
CTA torace	$2.3 \cdot 10^6$ (4)	2200 (1100 – 4200)	2700 (1300–5000)
.....			
.....			
TOTALE	$56.9 \cdot 10^6$ (100)	18000 (9000 – 28000)	29000 (15000–45000)

Berrington de González A, et al. Arch. Internal Med., Dec. 2009



Variazione di dose efficace per diversi tipi di esami CT

Smith-Bindman R, et al., Arch. Internal Med, Dec. 2009



Variazione di dose efficace per diversi tipi di esami CT

Smith-Bindman R, et al., Arch. Internal Med, Dec. 2009

Stima del numero di pazienti che comporta lo sviluppo di 1 cancro correlato a radiazione da CT, in funzione di età e sesso

	donna			uomo
Tipo di CT	20 anni mediana (range)	40 anni mediana	60 anni mediana	40 anni mediana
Testa routine	4360 (3290 – 5110)	8100	12250	11080
Torace no contrasto	390 (290 – 630)	720	1090	1566
Angiografia coronarica	150 (130 - 230)	270	420	595
Addome pelvi multifase	250 (180-370)	460	700	498
. . . . .				

Smith-Bindman R, et al., Arch. Internal Med, Dec. 2009

Si valuta per una donna di 20 anni, in angiografia coronaria, un rischio associato è 1/ 150.

L'attenzione sul fatto che CT possa indurre più tumori di quanto atteso cresce soprattutto per esami CT condotti in pazienti asintomatici, mentre in generale CT è considerata avere un favorevole rapporto beneficio / rischio per i pazienti sintomatici.

Il rischio piccolo ma comunque reale di cancerogenesi nell'uso di CT è importante che venga preso in considerazione in particolare nei pazienti più giovani.

L'adozione di specifici protocolli standard aiutano a ridurre la dose, in particolare negli USA dove si lamenta una scarsa messa in pratica di linee guida, forse in relazione al fatto che non vi sono associati componenti regolatori.

Ad es. FDA per CT chiede alle ditte le dosi per fantocci, usando setting ideali, e non procede a regolamentare le dosi associate alle applicazioni cliniche, come invece avviene per la mammografia.

E' spesso riconosciuto che in Europa da tempo sono in atto strategie di riduzione di dose e standardizzazione.

(Nagel HD, et al. *5 years of "concerted action dose reduction in CT"–what has been achieved and what remains to be done?* 2004)

(Greess H, et al. *Dose reduction in computed tomography by attenuation-based on-line modulation of tube current: evaluation of six anatomical regions. Eur Radiol.* 2000).

Effective dose:
how should it be applied to medical exposures?

C. J. Martin The British Journal of Radiology, 2007

La dose efficace E non si riferisce direttamene al rischio relativo in un individuo in quanto vi sono differenze fra sesso, con l'età dell'esposizione e differenze soggettive.

La dose efficace è nata per scopi radioprotezionistici, tuttavia è usata molto anche per esposizioni mediche.

L'uso di E per stimare il rischio sul singolo individui è inopportuno.

Si tende a dare ad E una affidabilità maggiore di quella che godono le sue basi.

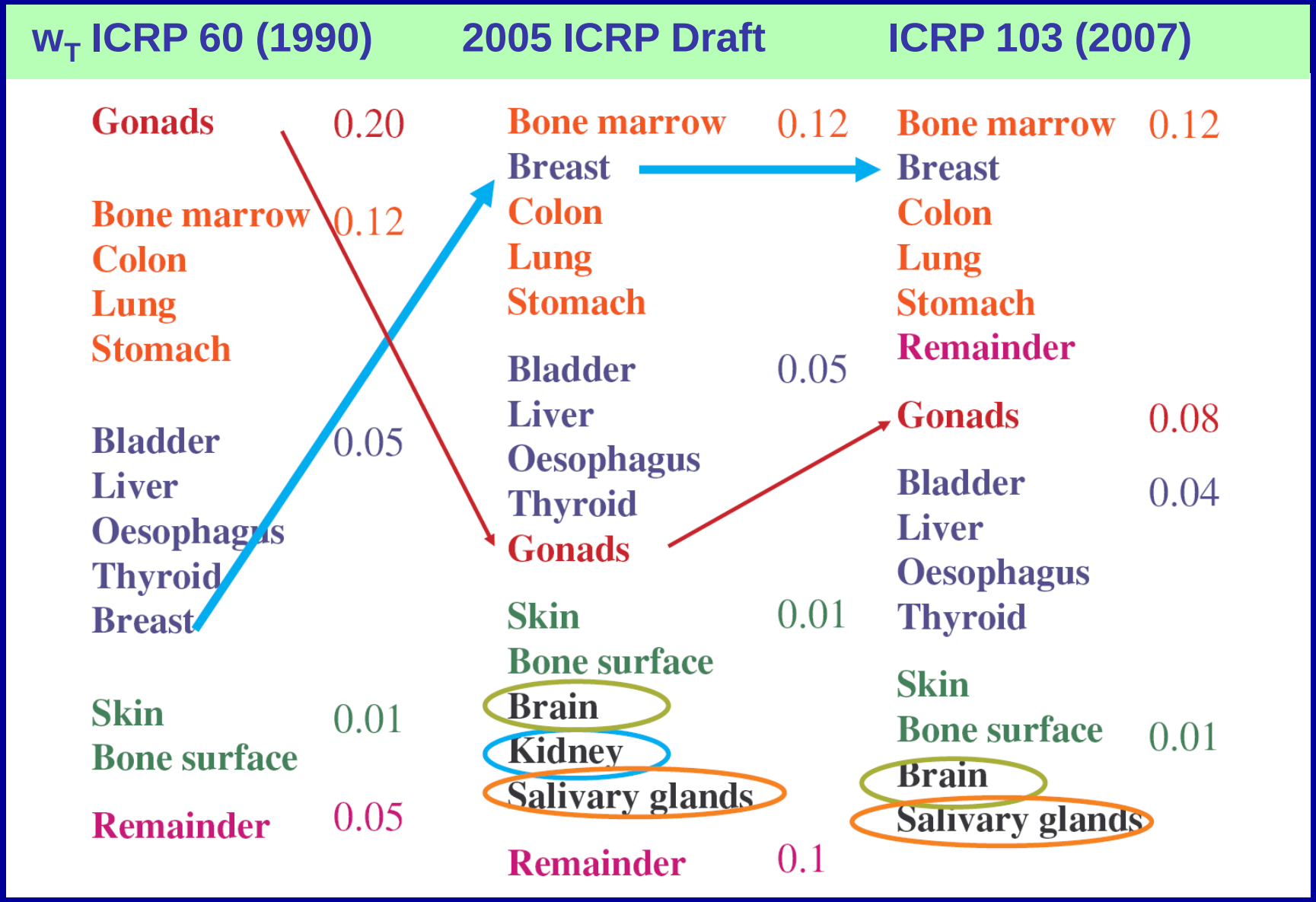
E è una grandezza conveniente nella giustificazione di esposizioni mediche

E è ben utilizzata nell'ottimizzazione radiologica

E si applica come indicatore generico legato al rischio di detrimento sanitario ad un paziente di riferimento e può essere usata per confrontare tipi di procedure e differenti tecniche.

Se si includono le incertezze nella valutazione di E, il rischio stimato per un paziente di riferimento potrebbe essere maggiore o minore dei valori indicati per un fattore 3 e quello per l'individuo per un fattore 5.

C. J. Martin The British Journal of Radiology, 2007


w_T ICRP 60 (1990)
2005 ICRP Draft
ICRP 103 (2007)
Gonads 0.20
Bone marrow 0.12
Colon
Lung
Stomach
Bladder 0.05
Liver
Oesophagus
Thyroid
Breast
Skin 0.01
Bone surface
Remainder 0.05
Bone marrow 0.12
Breast
Colon
Lung
Stomach
Bladder 0.05
Liver
Oesophagus
Thyroid
Gonads
Skin 0.01
Bone surface
Brain
Kidney
Salivary glands
Remainder 0.1
Bone marrow 0.12
Breast
Colon
Lung
Stomach
Remainder
Gonads 0.08
Bladder 0.04
Liver
Oesophagus
Thyroid
Skin
Bone surface 0.01
Brain
Salivary glands

Ancor prima del report NRCP, 2009, studi recenti indicano che da 1% al 3% dei tumori può essere attribuito, nei diversi paesi, ad esposizione medica da diagnostica per imaging.

Berrington de Gonzalez A,. Risk of cancer from diagnostic x-rays: estimates for the UK and 14 other countries Lancet 2004.

Nella comunità medica e nei media accresce la preoccupazione e i pazienti chiedono informazioni sul loro proprio rischio.

Già nel 2004 si lamentava che ai pazienti non vengono date sufficienti informazioni su rischi e benefici della CT scan.

Lee CI, Haims AH et al. Diagnostic CT Scans: Assessment of Patient, Physician, and Radiologist Awareness of Radiation Dose and Possible Risks. Radiology, 2004.



E' disponibile un sito che permette al singolo individuo di tracciare la storia di diagnostica per immagine e stimare il

"PROPRIO RISCHIO PERSONALE" !?

www.xrayrisk.com : Radiation Risk Calculator -- Calcul...

Pagina

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RADIATION RISK CALCULATOR

Dedicated to improving the understanding of radiation risks from medical imaging. Calculate your dose and estimate cancer risk from studies including CT scans, x-rays, nuclear scans and interventional procedures.

www.X-rayRisk.com

home | about | faq's | calculate your risk | glossary | contact

This site provides information for patients and health care providers to facilitate well-informed discussions about the increased risk of cancer from radiation exposure as a result of medical imaging.

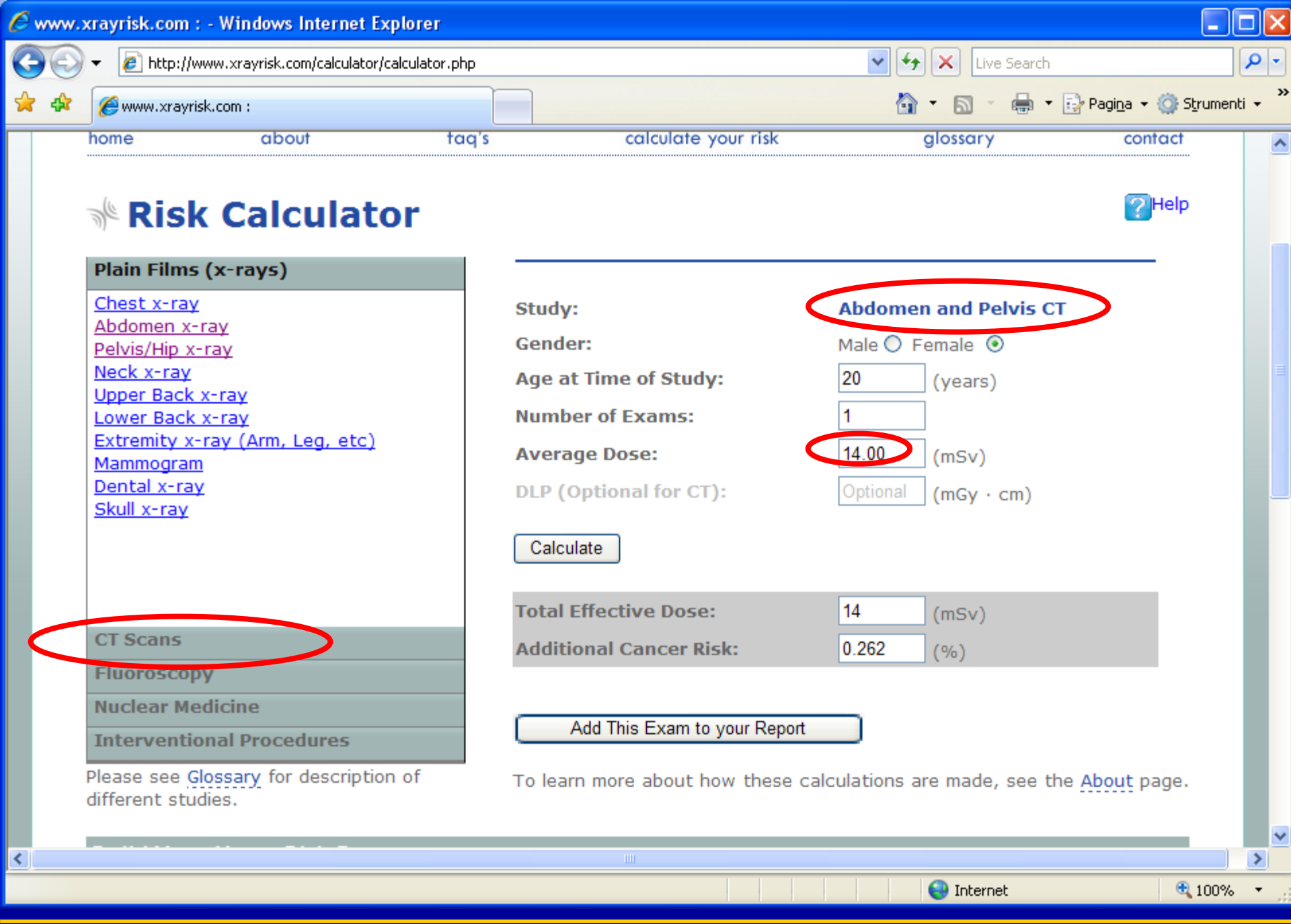


CALCULATE YOUR RISK

Internet

In questo sito - Informazioni di base al Pubblico

- **Non vi sono studi che forniscono correlazione diretta** fra incremento di cancro e diagnostica per immagine.
- La relazione fra esposizone a radiazione e cancro **si basa sui dati dei sopravvissuti**, di incidenti nucleari e dei primi usi dei raggi X.
- L'assunzione di incremento di cancro da basse dose di esposizioni mediche si basa su informazioni su **individui esposti ad alte dosi.**
- **La teoria usata della LNT è** in generale accettata dalla comunità scientifica
- Sforzi sono sostenuti dalla comunità scientica **per assicuare la safety del paziente mentre** si forniscomo le immagini diagnostiche
- E' importare notare che per un **esame condotto in modo appropriato i benefici potenziali** vanno oltre i rischi potenziali dell'esposizione.
- Il paziente non dovrebbe esitare su un **esame se è stato indicato da un punto** di vista medico.- questo sito fornisce informazioni per facilitare la discussione informata sui rischi da tumore per esposizioni a basse dosi.
- **Il sito inoltre consente di creare un Risk Report** con le informazioni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http://www.xrayrisk.com/calculator/calculator.php
Live Search
www.xrayrisk.com :
Pagina
Strumenti
home
about
faq's
calculate your risk
glossary
contact
Risk Calculator
Help
Plain Films (x-rays)
Chest x-ray
Abdomen x-ray
Pelvis/Hip x-ray
Neck x-ray
Upper Back x-ray
Lower Back x-ray
Extremity x-ray (Arm, Leg, etc)
Mammogram
Dental x-ray
Skull x-ray
CT Scans
Fluoroscopy
Nuclear Medicine
Interventional Procedures
Please see Glossary for description of different studies.
Study:
Abdomen and Pelvis CT
Gender:
Male
Female
Age at Time of Study:
20
(years)
Number of Exams:
1
Average Dose:
14.00
(mSv)
DLP (Optional for CT):
Optional
(mGy · cm)
Calculate
Total Effective Dose:
14
(mSv)
Additional Cancer Risk:
0.262
(%)
Add This Exam to your Report
To learn more about how these calculations are made, see the About page.
Internet
100%

www.xrayrisk.com : - Windows Internet Explorer
http://www.xrayrisk.com/calculator/calculator.php
Live Search
www.xrayrisk.com :
Pagina
Strumenti

different studies.

Build Your X-ray Risk Report

Study	Gender	Age	# of exams	Dose (mSv)	Additional Cancer Risk(%)	
Abdomen and Pelvis CT	Female	20	1	14	0.262%	✕
					0.262%	

Comparison Doses

Natural Background	3.1 mSv/year[10]	**Domestic Pilots**	2.2 mSv/year[11]
Average US Exposure	6.2 mSv/year[10]	**7 Hour Airline Flight**	0.02 mSv/year[11]

Keep in mind, the overall lifetime risk of developing an invasive cancer is 37.5% (1 in 3) for women and 44.9% (1 in 2) for men regardless of imaging history. These statistics are averages and do not predict what is going to happen to you. They do not take into consideration individual risk factors including lifestyle (smoking, diet, exercise, etc), family history (genetics) or radiation exposure. The majority of cancers occur later in life and the average lifetime risk of dying from cancer is 25% (1 in 4).

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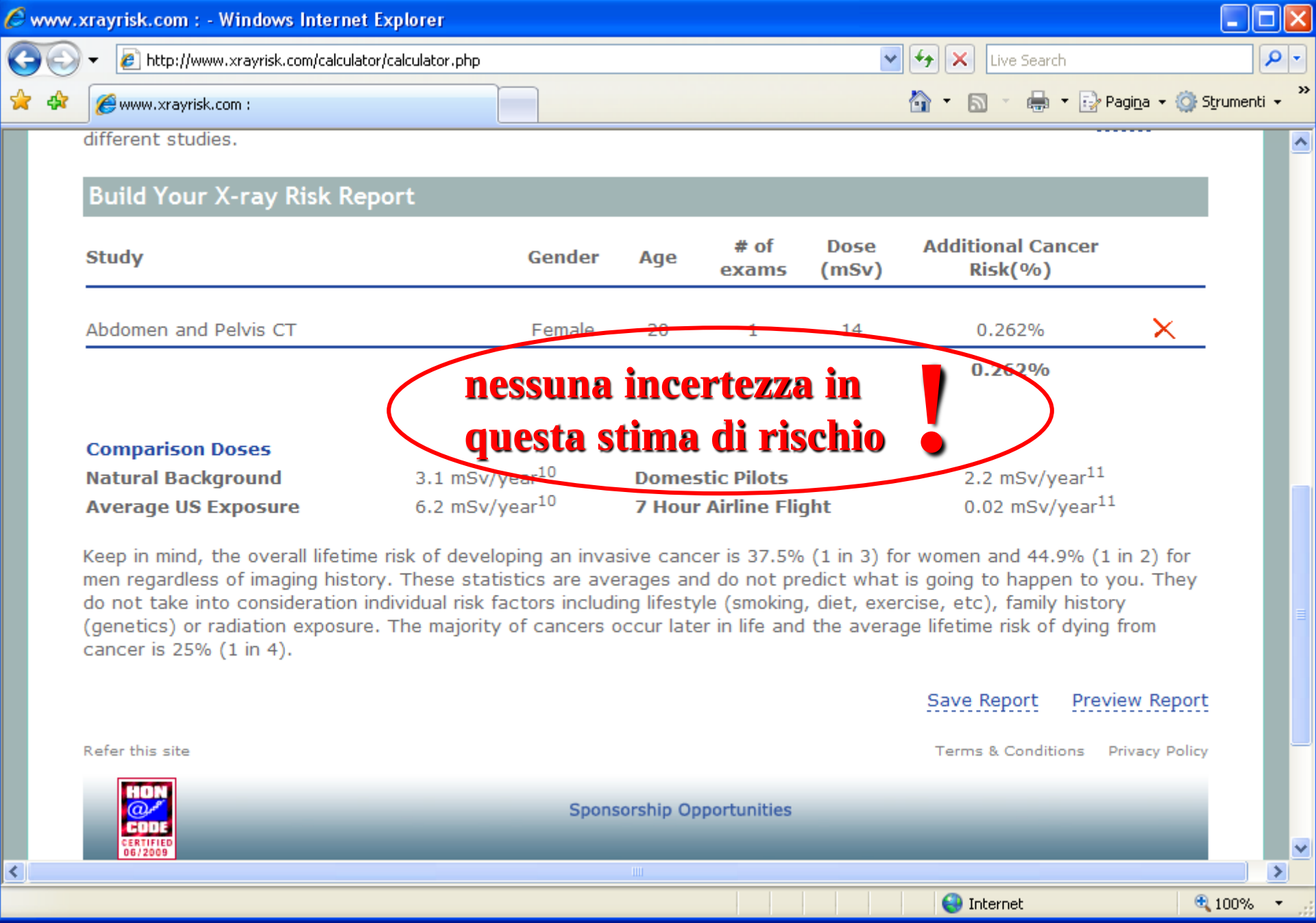
www.xrayrisk.com : - Windows Internet Explorer
http://www.xrayrisk.com/calculator/calculator.php
Live Search
www.xrayrisk.com :
Pagina
Strumenti
different studies.
Build Your X-ray Risk Report
Study
Gender
Age
# of exams
Dose (mSv)
Additional Cancer Risk(%)
Abdomen and Pelvis CT
Female
20
1
14
0.262%
0.262%
nessuna incertezza in questa stima di rischio
!
Comparison Doses
Natural Background
3.1 mSv/year10
Average US Exposure
6.2 mSv/year10
Domestic Pilots
2.2 mSv/year11
7 Hour Airline Flight
0.02 mSv/year11
Keep in mind, the overall lifetime risk of developing an invasive cancer is 37.5% (1 in 3) for women and 44.9% (1 in 2) for men regardless of imaging history. These statistics are averages and do not predict what is going to happen to you. They do not take into consideration individual risk factors including lifestyle (smoking, diet, exercise, etc), family history (genetics) or radiation exposure. The majority of cancers occur later in life and the average lifetime risk of dying from cancer is 25% (1 in 4).
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100%

- **Indicare un rischio numerico di cancro può dare una impressione di certezza che non è giustificata.**
- **Si può invece sviluppare una terminologia per descrivere il rischio da esposizione medica da usare con pazienti e familiari.**

E (mSv)	Lifetime risk of fatal cancer[(a)]	Proposed risk term	Examples of medical exposures
<0.1	1 in 1 million	Negligible	Radiographs of chest, limbs, head, neck and teeth; nuclear medicine ^{14}C breath test
0.1–1	1 in 100 000	Minimal	Radiographs of spine, abdomen and pelvis; nuclear medicine lung ventilation scans
1–10	1 in 10 000	Very low	Barium meals and enemas, CT scans of head, chest and abdomen; coronary angiography and angioplasty; nuclear medicine bone and lung perfusion scans
10–100	1 in 1000	Low	Contrast enhanced CT scans, or series of CT scans; higher dose interventional radiology or cardiology procedures; nuclear medicine ^{201}Tl myocardial imaging
>100	>1 in 100	Moderate	Multiple CT scans, multiple interventional radiology or cardiology procedures

Colin J. Martin, Editorial -The application of effective dose to medical exposures, Radiation Protection Dosimetry 2007

Non tutti gli esperti concordano sulle stesse stime di rischio di cancro attribuibile alla diagnostica medica, ma è condivisa da tutti la necessità di porre attenzione alle esposizioni mediche.

"Managing the risks of computed tomography (CT), fluoroscopy, and nuclear medicine imaging procedures depends on two principles of radiation protection: appropriate justification for ordering and performing each procedure, and careful optimization of the radiation dose used during each procedure"

FDA, 2010

"When used appropriately, diagnostic imaging delivers tremendous benefit and value"

Effective dose

Effective dose is not based on data from any one individual person, and <u>does not provide an individual-specific dose</u> but rather that for a reference person under a given exposure situation.

For radiological protection,

→ a single value of effective dose is applied for both sexes

w_T are sex and age-averaged values for all organs and tissues,

This approach is restricted to the determination of effective dose in radiological protection and, in particular, <u>it is not intended to be used for the assessment of individual risks.</u>

Effective dose and risk

Effective dose is used prospectively for planning and optimization purposes and retrospectively for demonstrating compliance with dose limits and constraints.

At the same time E is prone to misuse, particular in the medical radiological field (when E is calculated, and then lifetime cancer risks are estimated from these effective doses - in literature on CT example where E and H are confused one another, but E is approax 1/3 of H).

We can do better than effective dose for estimating or comparing low-dose radiation risks (D.J. Brenner, ICRP vol 41, Dec 2012)

proposta specifica dell'autore

A new quantity "effective risk", which has the potential to be age- and gender-specific if desired, would perform the same comparative role as effective dose, be just as easy to estimate, be less prone to misuse, be more directly understandable, and would be based on solid science.

Effective dose and risk in radiology (x-ray)

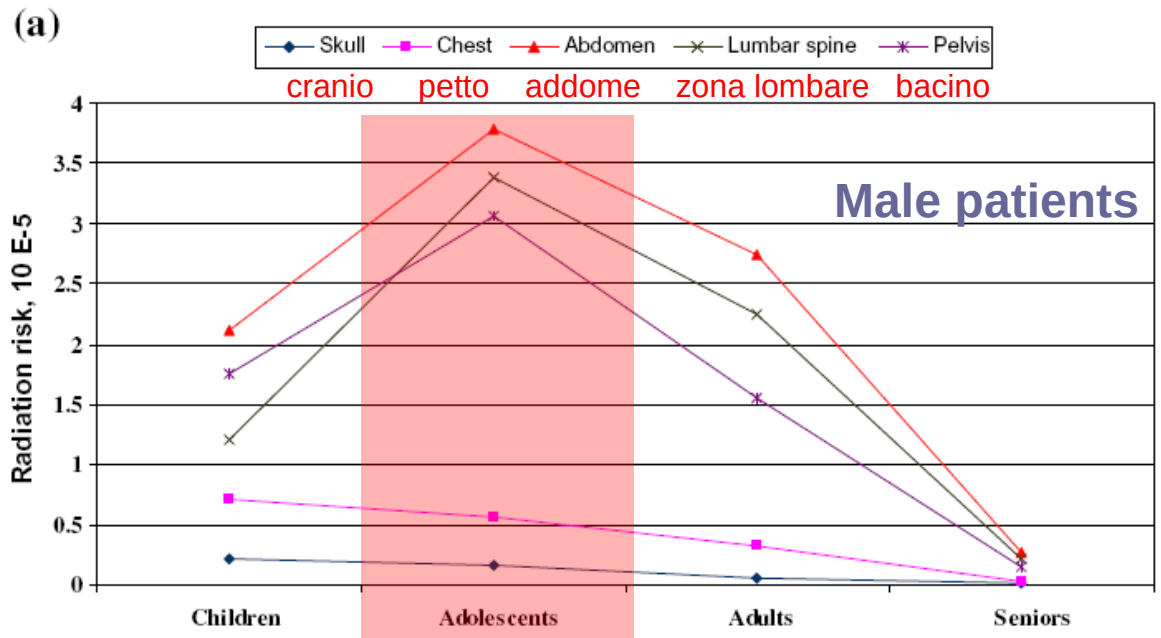
The significant sex and age dependence of radiogenic risk for different cancer types is an important consideration when planning x-ray examinations.

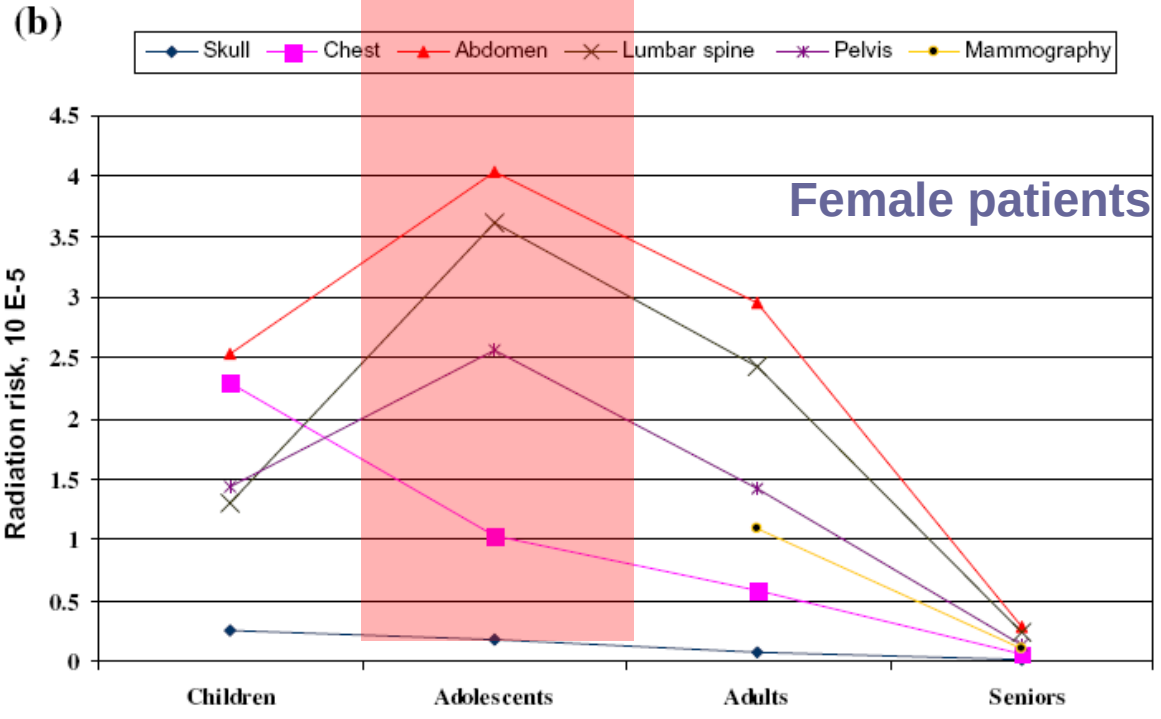
Radiation risks from Medical x-ray Examinations as a function of the Age and Sex of patient (B.F. Wall et al. HPA report October 2011)

Effective dose and risks from medical x-ray procedures (M.I. Balonov, P.C. Shrimpton, ICRP vol 41, Dec 2012)

ICRP (Publ. 103) risk models were used to calculate the life-time risks of radiation-induced cancer per unit dose as a function of organ, sex, and age at exposure.

Six selected radiographic x-ray examinations : skull, chest, abdomen, pelvis, lumbar spine, mammography





Life-time radiation risks for various age groups of male and female patients due to a single radiographic examination, for six selected x-ray examinations.

Risk is higher in children and adolescence and decrese with age

Risk for chest in pedriatric patients exceed that for adult by a factor 4, and when are examinated the body area where the dose strongly depends on body thickness, adolescents are at maximum risk

M.I. Balonov, P.C. Shrimpton, 2012

Table 7. Typical total lifetime risk of cancer induction per x-ray examination by age and sex.

Examination	Sex	Risk per million (10^{-6}) by age at exposure (years)				
		0–9	20–29	40–49	60–69	80–89
Chest	M	1.3	0.9	0.7	0.5	0.1
	F	1.9	1.4	1.2	0.8	0.2
Head	M	12	5.9	3.2	1.3	0.3
	F	11	5.3	2.9	1.0	0.2
Ba follow	M	170	100	66	30	6.4
	F	140	91	61	28	5.4
Coronary angiography	M	330	250	210	150	41
	F	430	370	370	270	66
CT chest + abdomen + pelvis	M	960	630	440	240	58
	F	1500	910	640	360	80

CT, computed tomography; M, male; F, female. M.I. Balonov, P.C. Shrimpton, ICRP vol 41, 2012

Table 8. Comparison between age- and sex-specific risk coefficients for cancer incidence for x-ray examinations and ICRP nominal risk coefficients for detriment-adjusted cancer.

Source of data	Scope of data	Population	Risk/effective dose (%/Sv)
Wall et al. (2011)	Range in risk of cancer incidence/ effective dose for both sexes and all examinations	0–9 years 30–39 years 60–69 years	7.8–20 2.8–9.2 0.8–6.8
ICRP (2007)	Nominal risk coefficient for detriment-adjusted cancer	Whole Adult	5.5 4.0

5 % /Sv

Table 9. Total lifetime cancer risk per unit effective dose (% per Sv) as a function of age at exposure and sex for x-ray examinations conducted in different regions of anatomy.

Anatomical region	Sex	Age at exposure (years)				
		0–9	20–29	40–49	60–69	80–89
Head	M	18	9.1	5.2	2.2	0.5
	F	15	7.6	4.6	1.7	0.3
Neck	M	9.1	4.1	2.0	0.8	0.2
	F	20	7.2	2.6	1.0	0.2
Chest	M	8.3	5.8	4.6	3.0	0.8
	F	14	10	8.3	5.4	1.3
Abdomen and pelvis	M	12	7.5	4.7	2.2	0.4
	F	10	6.6	4.4	2.0	0.4
Whole body	M	10	6.2	4.2	2.2	0.6
	F	14	8.5	5.8	3.1	0.7

M, male; F, female.

M.I. Balonov, P.C. Shrimpton, ICRP vol 41, 2012

New sets of age and sex specific cancer risk per unit effective dose have been defined for different regions of examination ***in order to facilitate the improved assessemnt of risk from x-ray examinations***

Reazioni Tissutali, Effetti deterministici

Limite di equivalente di dose al cristallino

La cataratta è una delle cause principali di cecità, con il suo contributo del 51%.



Le principali cause di deficit funzioni visive sono:

- non corretta rifrazione (miopia, presbiopia, astigmatismo): **43%**
- cataratta: **33%**
- glaucoma: **2%**
- degenerazione maculare, retinopatia diabetica, tracoma e opacità corneale **1%**
- altre cause **18%**

(WHO, 2012. Global Data on Visual Impairments 2010)

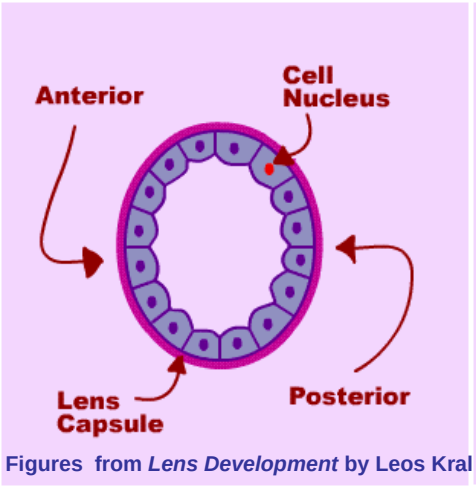
Struttura del cristallino

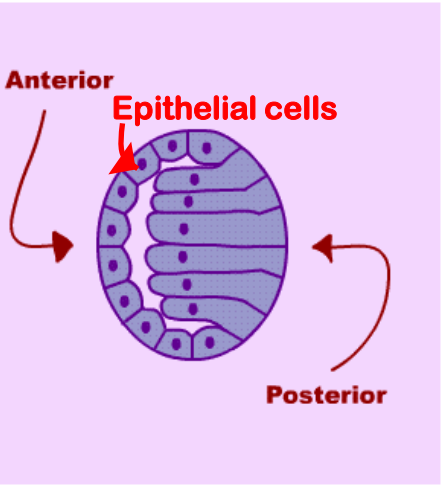


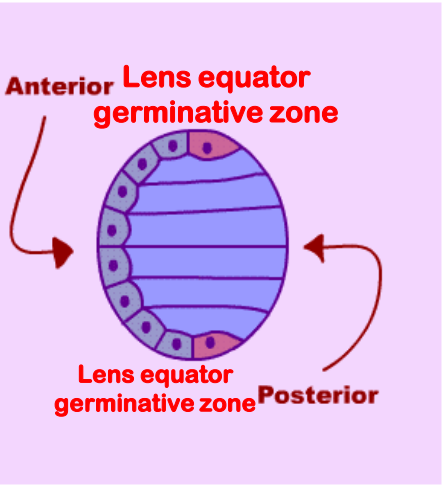
Il cristallino - tessuto elastico trasparente non vascolarizzato che riceve nutrimento dall' umore acqueo e vitreo circostanti.

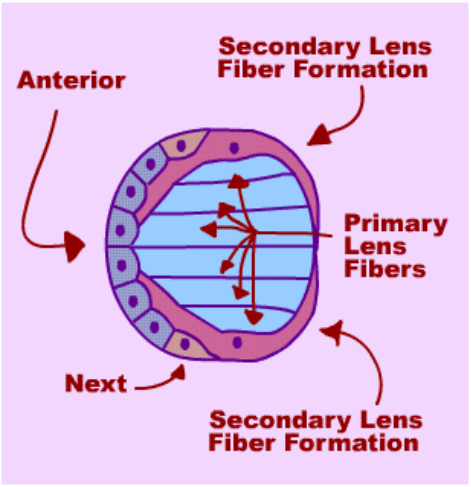
Sono distinguibili 3 strutture: la **capsula** (membrana elastica più esterna con spessore anteriore maggiore di quello posteriore); il **nucleo** (struttura centrale) circondato dalla **corteccia** (porzione con elevato livello metabolico)

Durante lo fase di sviluppo



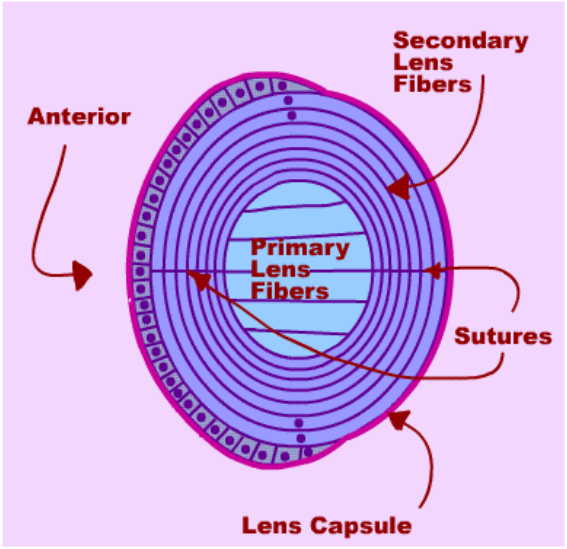




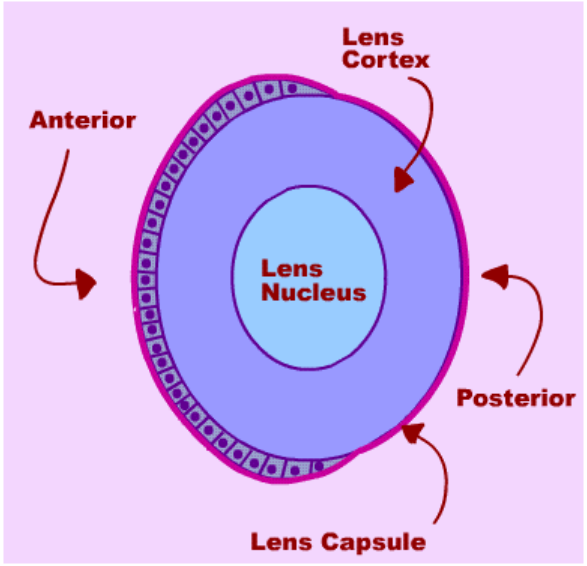


Figures from *Lens Development* by Leos Kral

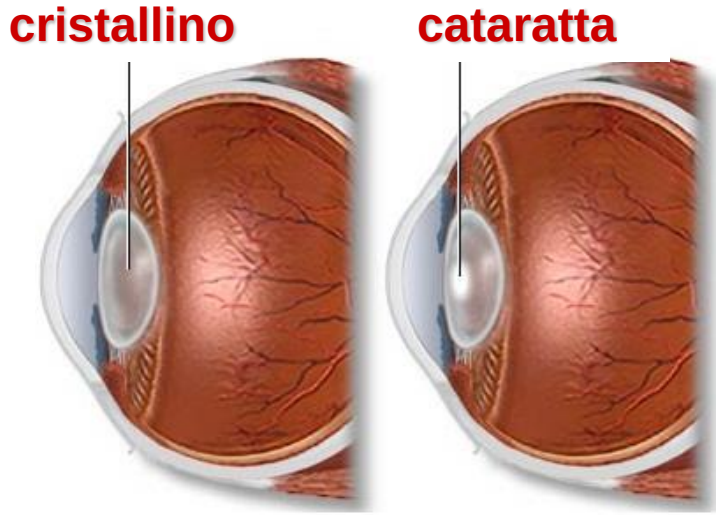
A sviluppo completo

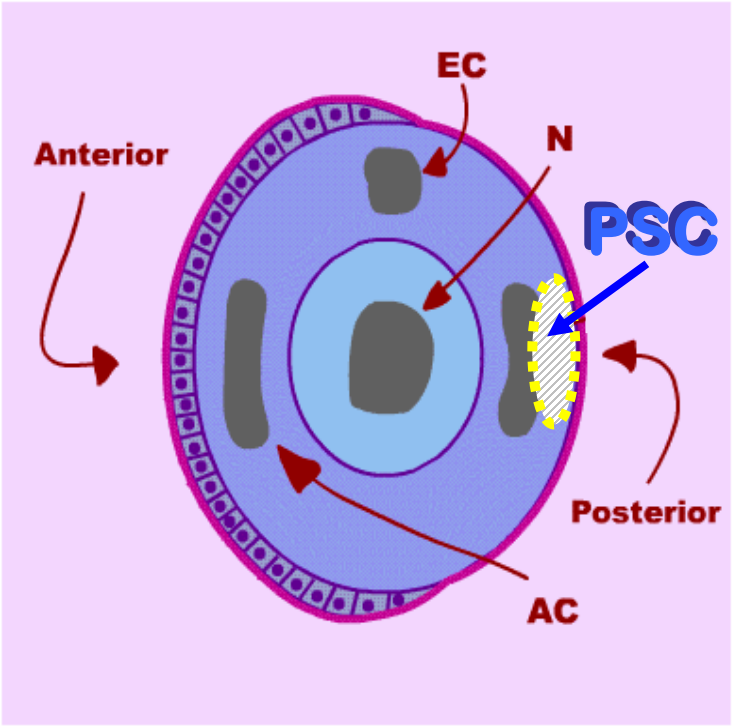


Le fibre primarie del cristallino formano il nucleo, mentre le fibre secondarie crescono nelle loro dimesioni e formano la corteccia.



La cataratta – offuscamento del cristallino a gradi diversi (leggera o completa opacità che ostruisce il passaggio di luce)





La cataratta è classificata secondo la localizzazione, oltre che la forma e dimensione.

PSC - posterior subcapsular cataract
EC - equatorial cortical cataract
AC - anterior cortical cataract
N - nuclear cataract

I meccanismi precisi di induzione di cataratta da parte delle radiazioni ionizzanti non sono completamente noti. (Anisbury et al. 2009)

I fattori di rischio per la cataratta includono:

- **Invecchiamento (**associata all'età, comunemente cataratta del *nucleo*, ma anche in regione *corticale***)**
- **Il rischio per le donne è maggiore**
- **Predisposizione genetica (**a livello etnico e familiare**)**
- **Radiazioni NIR (**UV e IR generalmente associate con cataratta *corticale***)**
- **Fumo (**associato con cataratta del *nucleo***)**
- **Altro (**agenti farmacologici come corticosteroidi; diabete e altri disturbi a livello renale, nervoso centrale, scheletrico … associati a cataratta *PSC* e *corticale***)**
- **Radiazioni Ionizzanti (**associate *PSC*, ma anche a *anteriore* e *corticale***)**

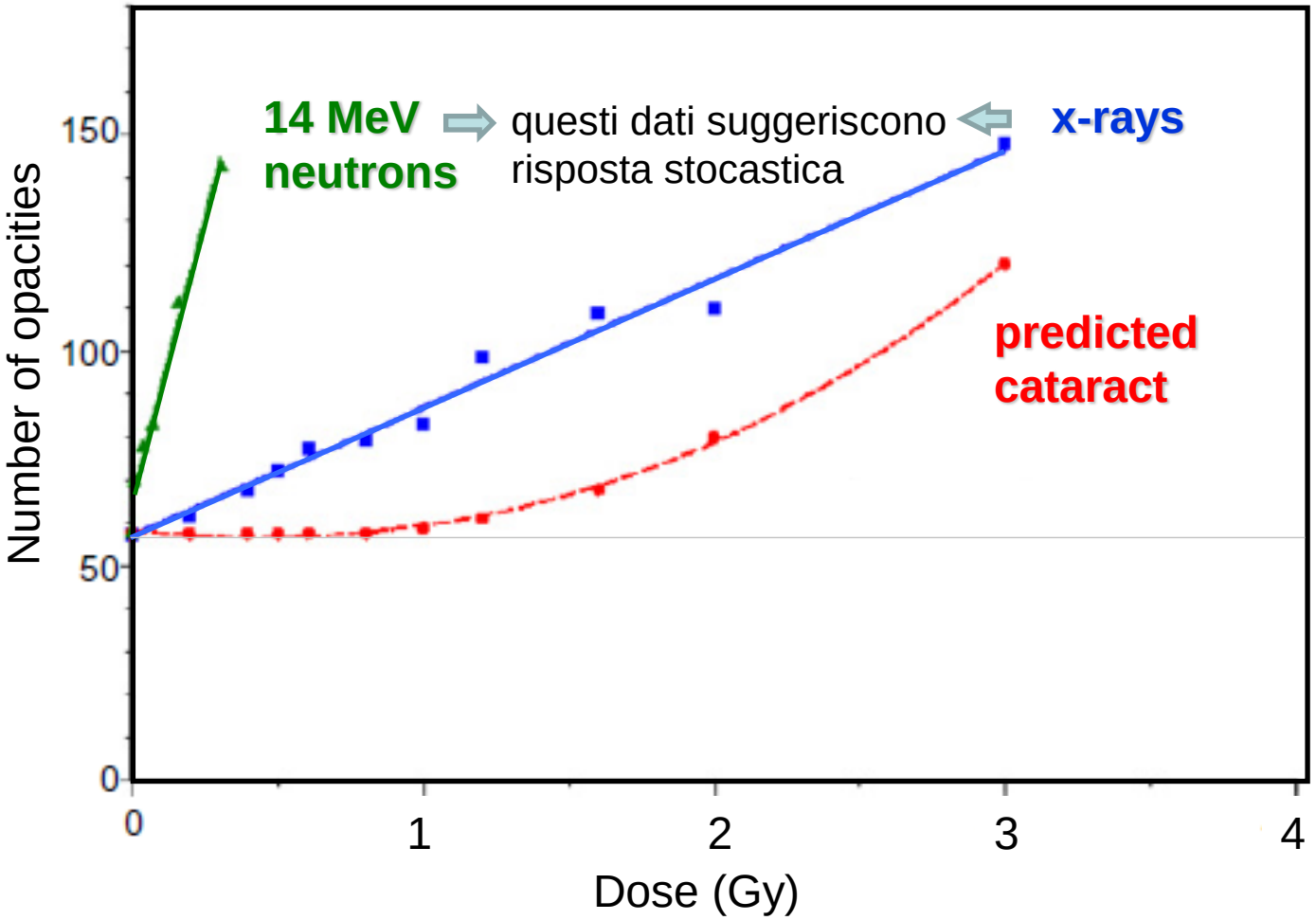
Cataratta associata alle radiazioni e radioprotezione

Studi epidemiologici e sperimentazione su animali suggeriscono che la cataratta può essere indotta a seguito di esposizioni a IR a **dosi significativamente più basse di quanto assunto in precedenza** e che la cataratta da radiazioni possa essere **considerata un effetto stocastico** (ICRP 118 §251, §264)

l'esistenza di una dose soglia è un punto critico

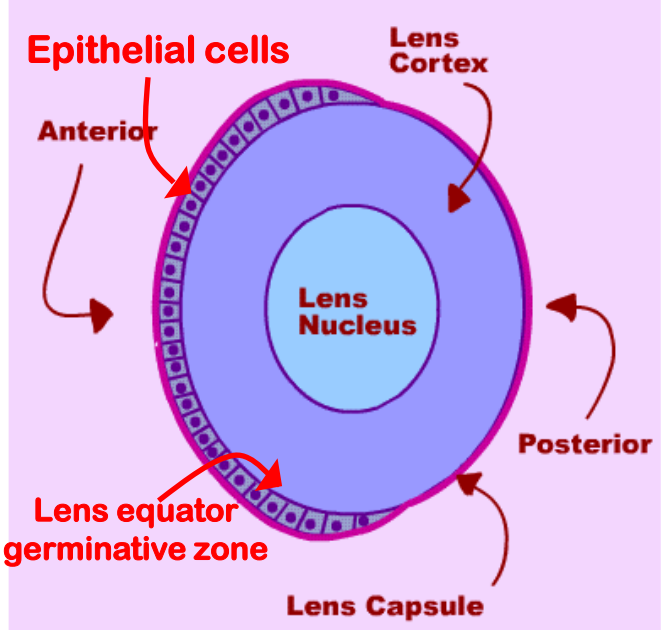
- Il periodo di latenza cresce al diminuire della dose - nei primi studi era considerato un periodo di osservazione breve
- Vi sono differenze negli approcci usati per documentare opacità associabili a radiazioni
- Vi sono differenze nella definizione clinica di cataratta da radiazioni
- Non esiste una unica opinione condivisa sul fatto che tutte le lesioni rilevabili al cristallino evolveranno in cataratta con disabilità visiva

"the purpose of RP is to prevent tissue-damaging effects of clinical significance and to limit effects to levels that are acceptable, modulated by societal concerns" (ICRP 118, §253)



Fig, 1 (da ICRP 118). Numero di opacità prodotte nella corteccia del cristallino di animali esposti a radiazioni ad alto (in verde) e basso (in blu) LET (Di Paola et al. 1978). Questo grafico suggerisce risposta stocastica. La curva tratteggiata (in rosso) rappresenta la previsione che si avrebbe se la cataratta risultasse da un danno accumulato su molte cellule, ovvero da una risposta deterministica.

Meccanismo ipotizzato per l'induzione cataratta da radiazione – danno iniziale su una singola cellula epiteliale



La formazione di cataratta può essere spiegata da un **danno iniziale su cellula epiteliale singola** che a seguito di divisione e differenziazione produce un gruppo di fibre cristalline difettose (risultato di una unica cellula epiteliale progenitore).

Questa ipotesi è supportata da lavori su animali (Worgul 1975, 1977…) che non mostrano cataratta da radiazioni quando viene inibita la divisione cellulare delle epiteliali o quando la porzione di cellule epiteliali è schermata da radiazioni.

Come prima fase si ipotizza un danno al DNA delle cellule epiteliali e un non corretto riparo. Il danno genomico risulta poi in fibre cristalline alterate. **In particolare le cellule della zona germinativa equatoriale migrano verso il polo posteriore ove diventano fibre cristalline opache**.

La formazione della cataratta dipende dalla sopravvivenza e differenziazione delle cellule epiteliali con genoma compromesso, più che dalla morte cellulare ad alte dosi.

formazione della cataratta



Cataratta come risultato del danno a molte cellule

→ **effetto deterministico**

Cataratta come risultato della mutazione di una singola cellula

→ **effetto stocastico**

Se la soglia per formazione cataratta da esposizione a radiazione è ZERO

→ **gli attuali standard di protezione per i lavoratori e anche per la popolazione possono/sono inadeguati**

"It is therefore **essential** for the risk-assessment community to **know whether visually disabling cataract formation is a stochastic response to radiation; a question that may be resolved in the future** by a combination of human epidemiological approaches and animal studies." (ICRP 118)

" .. current risk guidelines for ocular radiation safety require re-assessment" (ICRP 118)

Stime di dose soglia per induzione cataratta dagli studi

Table 4.3. Recent epidemiological studies of cataract formation where formal estimates of threshold doses were made. **(ICRP 118)**

Study	Cataract type	Threshold dose	Confidence intervals	Reference
Atomic bomb survivors (acute exposure)	Cortical cataract	0.6 Sv	90%: <0–1.2 Sv	Nakashima et al. (2006)
	Posterior subcapsular opacity	0.7 Sv	90%: <0–2.8 Sv	
Atomic bomb survivors (acute exposure)	Postoperative cataract	0.1 Gy	95%: <0–0.8 Gy	Neriishi et al. (2007)
Chernobyl clean-up workers (fractionated protracted exposure)	Stage 1–5 cataract	0.50 Gy	95%: 0.17–0.65 Gy	Worgul et al. (2007)
	Stage 1 cataract	0.34 Gy	95%: 0.19–0.68 Gy	
	Stage 1 non-nuclear cataract	0.50 Gy	95%: 0.17–0.69 Gy	
		0.34 Gy	95%: 0.18–0.51 Gy	
	Stage 1 superficial cortical cataract	0.35 Gy	95%: 0.19–0.66 Gy	
	Stage 1 posterior subcapsular cataract			

“ although the lower 95% CI in some threshold calculations includes zero dose, **there is no direct evidence that a single damaged progenitor lens epithelial cell can produce a cataract**, and hence radiation-induced lens cataract is still considered a tissue reaction (deterministic effect) with a dose threshold, albeit small

ELSEVIER

ICRP Publication 118

ICRP
Annals of the ICRP

ICRP Statement on Tissue Reactions

ICRP PUBLICATION 118, PART 1

Approved by the Commission on 21 April 2011

(.....)

(2) The Commission has now reviewed recent epidemiological evidence suggesting that there are some tissue reaction effects, particularly those with very late manifestation, where threshold doses are or might be lower than previously considered. For the lens of the eye, the threshold in absorbed dose is now considered to be 0.5 Gy.

(3) For occupational exposure in planned exposure situations, the Commission now recommends an equivalent dose limit for the lens of the eye of 20 mSv/year, averaged over defined periods of 5 years, with no single year exceeding 50 mSv.

(ICRP103) - Limiti di dose al cristallino in situazione di esposizione programmata

- **per esposizione lavorativa 150 mSv /a**
- **per popolazione 15 mSv/a**

Dose soglia e limiti per cristallino indicata da ICRP

(ICRP 103)-Stime di dose soglia sulla base di dati ICRP 41(1984)

	Dose totale ricevuta in una singola esposizione acuta	Dose totale ricevuta in esposizione frazionata o protratta
Opacità osservabile	**0.5 Gy - 2.0 Gy**	**5 Gy**
Cataratta	**5.0 Gy**	**>8 Gy**

(ICRP 118)- Stime di dose soglia sulla base dll'analisi di studi epidemiologici

Cataratta	0.5 Gy (95% CI incluso zero)	0.5 Gy *

* (le evidenze riguardano principalmente le opacità, piuttosto che cataratta, in quanto i tempi di follow-up sono minori)

ICRP 118 - ".. *the threshold dose for radiation-induced eye cataracts is now considered to be around 0.5 Gy* *for both acute and fractionated/chronic exposures,* *in line with various recent epidemiological studies*. "

Non sono raccomandati cambiamenti per i limiti di dose alla popolazione

I limiti attuali (15 mSv/y) per la popolazione sono giudicati adeguati.

Si ritiene improbabile che membri della popolazione ricevano una dose durante tutta la vita, che ecceda la soglia di 0,5 Gy in una situazione di esposizione programmata, considerando:

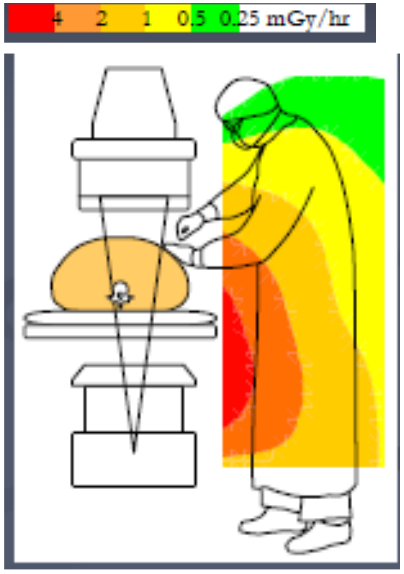
- l'applicazione dei limite dose efficace di 1 mSv

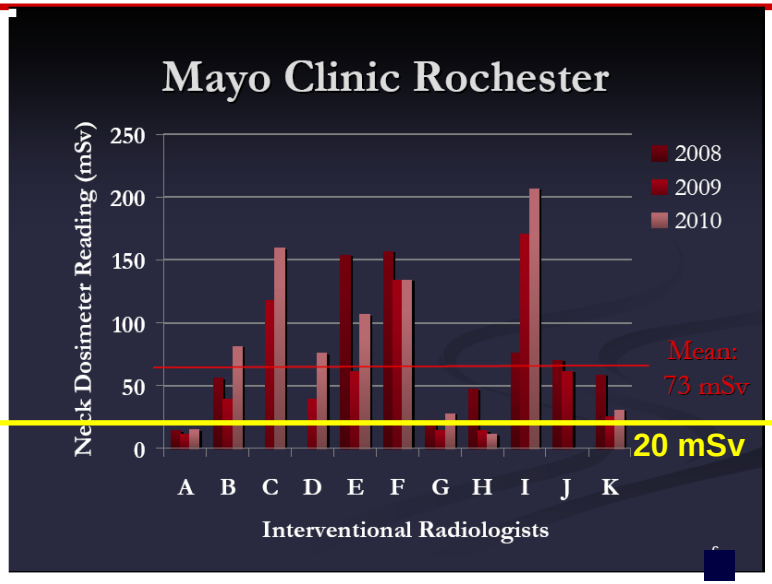
- la bassa probabilità che il cristallino sia esposto in via preferenziale per periodi significativi

- l'ottimizzazione della protezione al di sotto dei limiti di dose equivalente.

Non viene quindi giudicato nessun cambiamento del limite per la popolazione sulla base di miglioramenti nella protezione.

Implicazioni in campo medico – radiologia interventistica e cardiologia – ma anche in campo industriale e nucleare

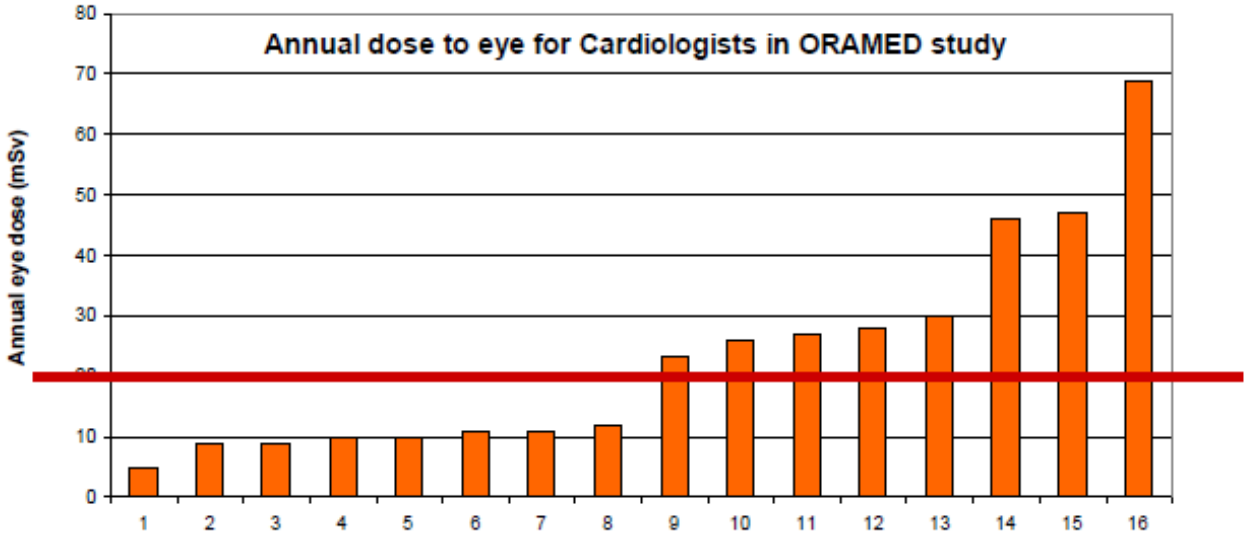




Es. di dose annue, dosimetro collare, in radiologia interventistica in USA

Beth Schueler, 2011 Radiation Safety for Staff in Fluoroscopy Suites.

ORAMED - Optimisation of RADiation Protection of MEDical staff -



ORAMED - A collaborative project funded in 2008 within the 7th EU FP, Euratom Programme for Nuclear Research and Training

The study covers: Belgium, France, Greece, Italy, Poland, Slovakia, Spain, Switzerland, Greece & Slovakia

http://www.oramed-fp7.eu/

Implicazioni in campo medico – radiologia interventistica e cardiologia

Necessità di tenere sotto controllo la dose al cristallino per alcune attività lavorative

→ quale dosimetro ? → in quale posizione portare il dosimetro ?

ICRP 103 –

(B 166) In the case of monitoring the dose to the lens of the eye, H'(3, Ω) with d = 3 mm was recommended by ICRU. The quantities directional dose equivalent, H'(3,Ω), and personal dose equivalent Hp(3), ***however, have rarely been used in practice and very few instruments exist for measuring these quantities****.*

It is suggested that their use is discontinued *because the monitoring of the exposure to the eye lens is also sufficiently achieved if the dose to the eye lens is assessed in terms of the other operational quantities. Hp(0.07) is normally used for this special purpose (ICRU 1998).*





E' in corso una ampia discussione su **quale grandezza sia più adeguata** per la dose equivalente al cristallino (es. Hp(0.07) ragionevole stima per Hp(3) per campo uniforme di fotoni, ma per beta si ha sovrastima). Inoltre, proprio per la posizione del cristallino, la dose dipende molto dalla direzione incidente per energie basse ed intermedie. Prosegue la ricerca e lo sviluppo di dosimetri per la dose al cristallino. (Gualdrini et al RPD 2011, EURADOS Report 2012-02 April 2012, ICRP 116, Behrens and Dietze 2010, 2011).

Impegno e coinvolgimento da parte della comunità RP

In questi anni sono emerse **riflessioni** e al tempo stesso **preoccupazioni** da parte della comunità internazione di RP per **una riduzione dei limiti di dose al cristallino di oltre 7 volte** (150 mSv → 20 mSv).

Ne è seguito un impegno da parte di organismi e associazioni coinvolte.

Alcuni organismi nazionali e internazionali, associazioni e strutture hanno aperto una *consultazione* agli stakeholder e/o hanno organizzato *giornate di studio, di informazione e meeting*. Numerosi esperti si sono dedicati a sviscerare le implicazioni e le *ricadute nella pratica giornaliera*. Si sono creati *gruppi di studio ad hoc* oppure il tema specifico della dose al cristallino è stato inserito in gruppo di lavoro già in corso.









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February 2012 Event

Impact on the Medical Sector of Revised Dose Limit for the Eye

8th February 2012, Royal Institution, London

Programme

Australian Government
Radiation Health Committee

Statement on Changes to Occupational Dose Limit for Lens of the Eye

(November 2011)

Australia's radiation dose limits are currently embodied in ARPANSA's Radiation Protection Series publication 1 (RPS 1), *Recommendations for Limiting Exposure to Ionizing Radiation* and *National Standard for Limiting Occupational Exposure to*

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

(FSME-11-084, September, Other, ICRP, Eye)

September 2, 2011

ALL AGREEMENT STATES

OPPORTUNITY TO COMMENT ON THE NEW INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION RECOMMENDATION TO THE LENS OF THE EYE (FSME-11-084)

The Sahlgrenska Academy

Evaluation of Eye Lens Doses Received by Medical Staff Working in Interventional Radiology at Sahlgrenska University Hospital

M.Sc. Thesis
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Supervisors:
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Department of Radiation Physics
University of Gothenburg
Gothenburg, Sweden
January 2012

UNIVERSITY OF GOTHENBURG

EURADOS
European Radiation Dosimetry Group e. V.

EURADOS Report 2012-02
Braunschweig, April 2012

ORAMED: Optimization of Radiation Protection of Medical Staff

Vanhavere F., Carinou E., Gualdrini G., Clairand I., Sans Merce M., Ginjaume M., Nikodemova D., Jankowski J., Bordy J-M., Rimpler A., Wach S., Martin P., Struelens L., Krim S., Koukorava C., Ferrari P., Mariotti F., Fantuzzi E., Donadille L., Itié C., Ruiz N., Carnicer A., Fulop M., Domienik J., Brodecki M., Daures J., Barth I., Bilski P.

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HPA response to the ICRP statement on tissue reactions and recommendation on dose limit for the eye lens

In April 2011, the ICRP released a statement on tissue reactions (www.icrp.org/publication.asp?id=ICRP%20Publication%20118) based on findings of a review of Early and late effects of radiation in normal tissues and organs (ICRP Publication 118, 2012). These documents indicate that the threshold dose for effects on the lens of the eye is now considered to be 0.5 Gy. The ICRP judgement is in line



ISS Istituto Superiore Sanità

Progetto: *Problematiche connesse alle esposizioni da radiazioni ionizzanti di operatori e pazienti in Radiologia Interventistica*

***Linee guida** per l'ottimizzazione della protezione dalle radiazioni del paziente e degli operatori nelle pratiche interventistiche con guida fluoroscopica*

AIRP, AIFM, AIRM, ANPEQ

Gruppo di Lavoro per il recepimento della nuova Direttiva EU di Radioprotezione "*Basic Safety Standards*".



The New York Times

Health

Radiation Raises Women's Risk of Heart Disease Only Slightly, Study Finds

By DENISE GRADY
Published: March 13, 2013 | 28 Comments

Radiation treatment for breast cancer can increase a woman's risk of heart disease, doctors have long known. But the size of the added risk has not been clear.

Enlarge This Image



Ozier Muhammad/The New York Times
In treating a patient for breast cancer,

Now, a new study offers a way to estimate the risk. It finds that for most women the risk is modest, and that it is outweighed by the benefit from the treatment, which can halve the recurrence rate and lower the death rate from breast cancer by about one-sixth.

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http://online.wsj.com/article/SB10001424127887324392804578358691452730124.html

THE WALL STREET JOURNAL.

EUROPE EDITION Wednesday, March 13, 2013 As of 5:10 PM EDT

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U.S. NEWS | March 13, 2013, 5:10 p.m. ET

Breast-Cancer Radiation Raises Heart Risk: Study

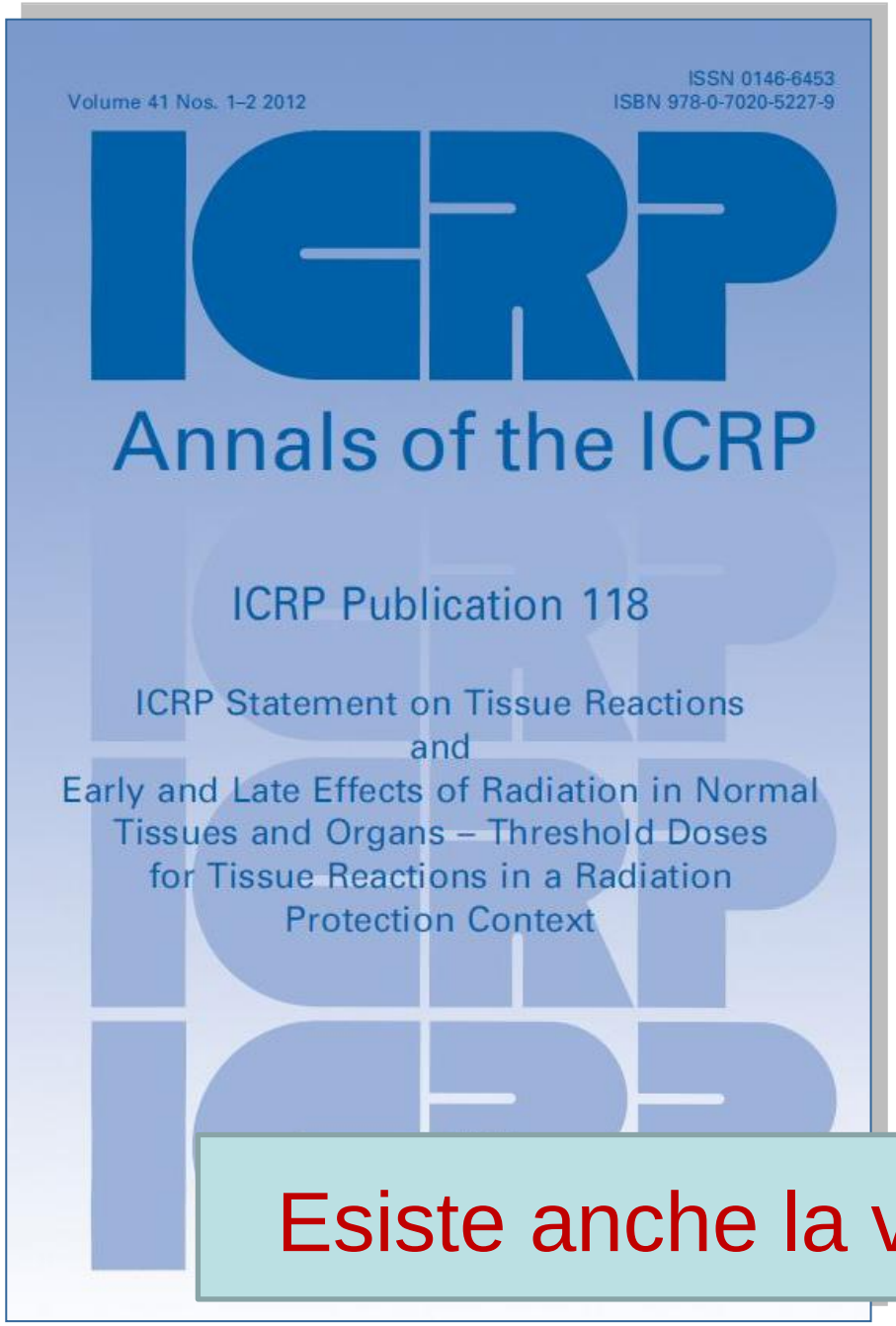
By MELINDA BECK

Women who had radiation therapy for breast cancer are at increased risk of having a heart attack or other major coronary event, according to a large European study published in the New England Journal of Medicine Wednesday.

The risk started climbing five years after treatment and continued for at least two decades, and the higher the dose of radiation the women's hearts received, the greater the risk of having a serious heart problem, the study found.

Breast-cancer experts stressed that radiation today can be targeted more precisely than when many of the women in the study were treated, lessening damage to surrounding tissue. They also said the findings didn't suggest that fewer breast-cancer patients should undergo radiation, but that they should be careful to manage other risk factors for heart disease as much as possible.

"It's important to put this in context: The reason we have this problem is that radiation and other advances in treatment have allowed so many women with breast cancer to survive



Annals of the ICRP

ICRP PUBLICATION 118

ICRP Statement on Tissue Reactions and Early and Late Effects of Radiation in Normal Tissues and Organs – Threshold Doses for Tissue Reactions in a Radiation Protection Context

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C.H. CLEMENT

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PUBLISHED FOR

The International Commission on Radiological Protection

by

ELSEVIER

Esiste anche la versione in italiano

Quale termine usare ?

ICRP 41, 1984

Non stochastic Effects of Ionizing Radiation

non-stocastic injury in populations of cells

ICRP 60, 1991

deterministic effects, causally determined by prededing events (the dose)

ICRP 103, 2007

tissue reactions (deterministic effects), subject to biological responce modifiers (dose modifying factors)

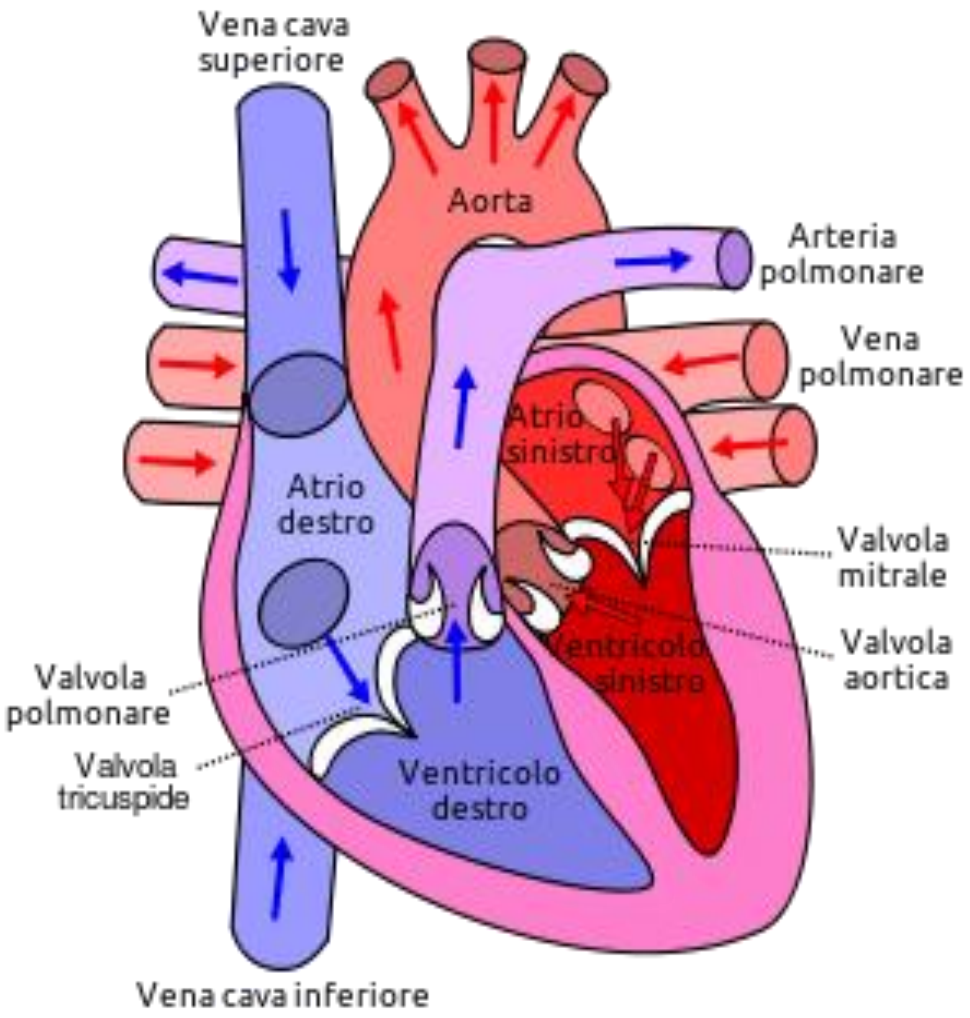
“This ability to modify the response of tissues and organs means that the term ‘deterministic effects’ is not entirely accurate because, quantitatively, the effects are not necessarily pre-determined.”

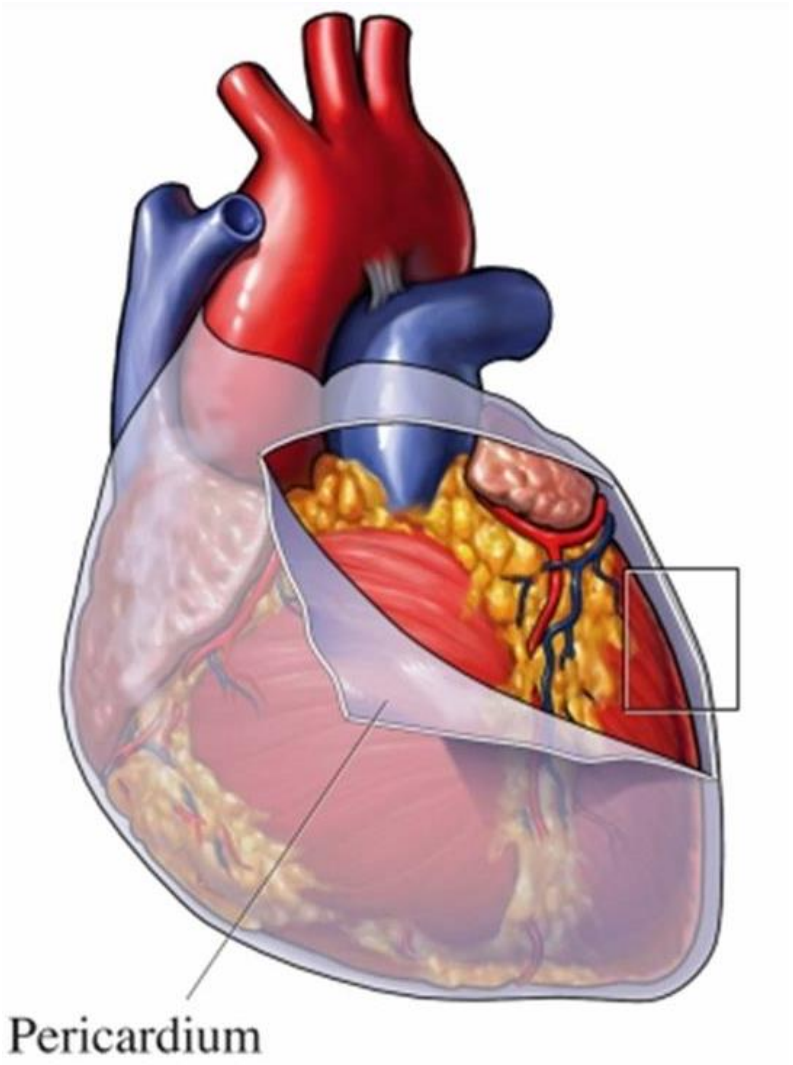
Reazioni tissutali

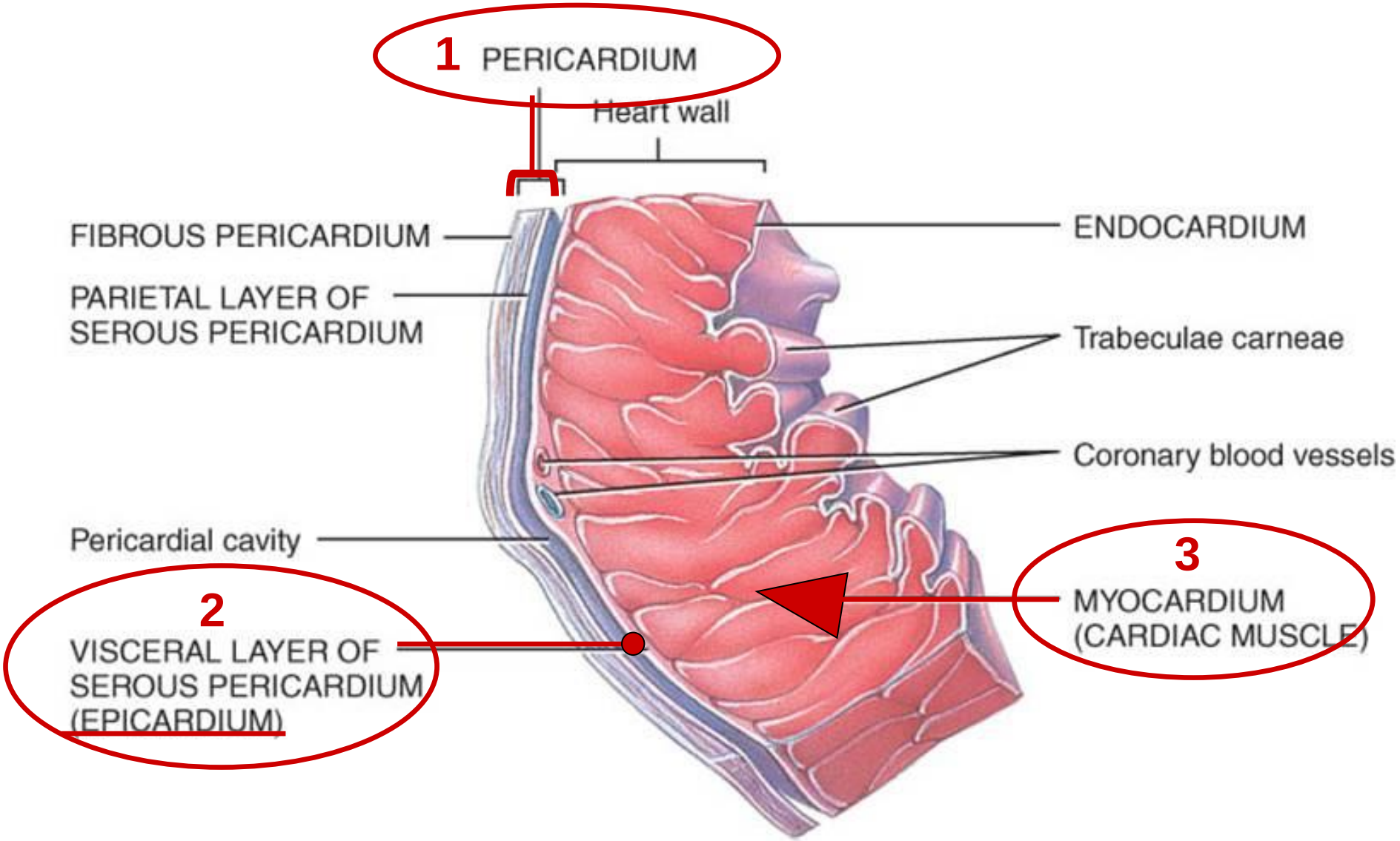
Ora si riconosce che sia le reazioni tissutali precoci che quelle tardive non sono necessariamente predeterminate, ed esse possono essere modificate dall'intervento di diversi modificatori della risposta biologica.

Le reazioni tissutali precoci
(da alcune ore ad alcune settimane)

Le reazioni tissutali tardive
-generiche
-consequenziali
(in una scala temporale di mesi o anni)


Vena cava superiore
Aorta
Arteria polmonare
Vena polmonare
Atrio sinistro
Atrio destro
Valvola mitrale
Valvola aortica
Ventricolo sinistro
Valvola polmonare
Valvola tricuspide
Ventricolo destro
Vena cava inferiore


Pericardium


1 PERICARDIUM
Heart wall
FIBROUS PERICARDIUM
PARIETAL LAYER OF SEROUS PERICARDIUM
ENDOCARDIUM
Trabeculae carneae
Coronary blood vessels
Pericardial cavity
2
VISCERAL LAYER OF SEROUS PERICARDIUM (EPICARDIUM)
3
MYOCARDIUM (CARDIAC MUSCLE)

Sistema cardiovascolare *è sempre stato visto come radioresistente a seguito della bassa attività di proliferazione di cellule del tessuto endoteliale e connettivo e dello stato postmitotico dei cardiomiociti.*

Quali possibili interpretazioni su una associazione di causalità con malattie cardiovascolari a seguito di esposizione a bassa o moderata dose, da un punto di vista dei meccanismi biologici ?

Meccanismi di danno

I meccanismi di induzione di danno al miocardio includono essenzialmente "processi infiammatori", in particolare a dosi più basse.

Per dosi crescenti si ha una progressiva riduzione del numero di capillari con conseguente possibile ischemia e morte delle cellule del miocardio, fibrosi e aterosclerosi accellerata per formazione di placche nei vasi principali, decrescita funzionale cardiaca.

Sistema circolatorio - Reazioni Tissutali

- **Le malattie circolatorie contribuiscono al 30-50% delle cause di morte nei paesi sviluppati.**
- **Principali cause di patologie e mortalità: patologie delle coronarie e del sistema cerebrovascolare, come manifestazioni di aterioscleros delle arterie.**
- **Patologie a cui contribuiscono molti fattori: fumo, dieta, slile di vita, fattori genetici……..**

Per dosi < 5Gy

Dati epidemiologici per malattie circolatorie associate ad esposizione a basse dosi richiedono attenzione riguardo ai fattori di confondimento

Incremento di rischio mortalità malattie vascolari per dosi da RT (ICRP 118)

Numero elevato di pazienti trattati RT tumore al seno, mortalità cardiaca in particolare correlata a vecchie tecniche RT

EBCTCG Early Brest Cancer Trialists Collaborative Group
23500 donne in 46 trials RT/chirurgia,
9300 donne in 17 trials RT/chirurgia estesa

Mostrato benefici RT su controllo locale e rischio morte tumore con eccesso rischio mortalità non cancro

Incremento di rischio mortalità malattie vascolari per dosi da RT (ICRP 118)

I dati di effetti cardiaci in pazienti trattati RT hanno come **fattore di confondimento addizionale i trattamenti di terapia sistemica con effetti cardiotossici** (anthracylines già fattore indipendente di mortalità cardiovascolare, trastuzumab).

La combinazione di queste terapie riduce intervallo di tempo insorgenza effetti cardiotossici.

La tossicità cardiaca da RT e/o chemioterapia attesa è crescente in futuro, **ma nel contempo** è previsto un miglioramento tecnico per riduzione dose al cuore e ai principali vasi.

IMRT, per malattia a primo stadio, aumenta la spettanza di vita, e in questo senso può rendere più evidenti malattie cardiache radioindotte

Osservazioni conclusive

ICRP 118

Dagli studi recenti si può valutare una soglia per dose acuta di 0.5 Gy sia per malattie cardiovascolari che cerebrali.

Ovvero una dose di 0.5 Gy può portare circa 1% degli individui esposti a sviluppare la malattia in questione dopo 10 anni dalla esposizione.

Questo in aggiunta al rate di incidenza naturale (per la malattie circolatorie è già fra 30-50 % di tutte le cause di morte nei paesi sviluppati).

Il valore di 0.5 Gy al cuore e al sistema cerebrovascolare può essere raggiunto durante complesse procedure di interventistica quindi importante ottimizzazione.

Osservazioni conclusive

ICRP 118

Non è ancora chiaro se la soglia è la stessa se si considerano esposizioni acute – frazionate – croniche. Qui la soglia è assunta essere la stessa (approx 0.5 Gy).

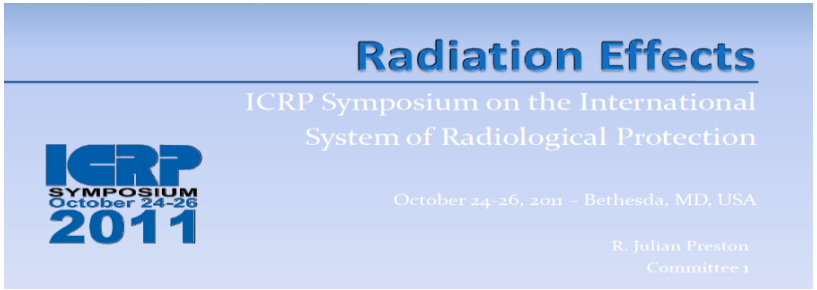
Il giudizio che ICRP aveva dato per dosi acute di 0.1 Gy che non produce functional impairment ai tessuti, rimane valido

Quindi il rischio stocastico di induzione tumore continua ad essere il rischio da tener presente sia nei lavoratori che nella popolazione .

Tuttavia sopra 0.5 Gy il rischio per reazioni ai tessuti in particolare per cristallino e per sistema circolatorio, a lungo termine, diventa di importanza crescente.

http://www.icrp.org/docs/Julian%20Preston%20Radiation%20Effects.pdf

R. Julian Preston
Committee 1

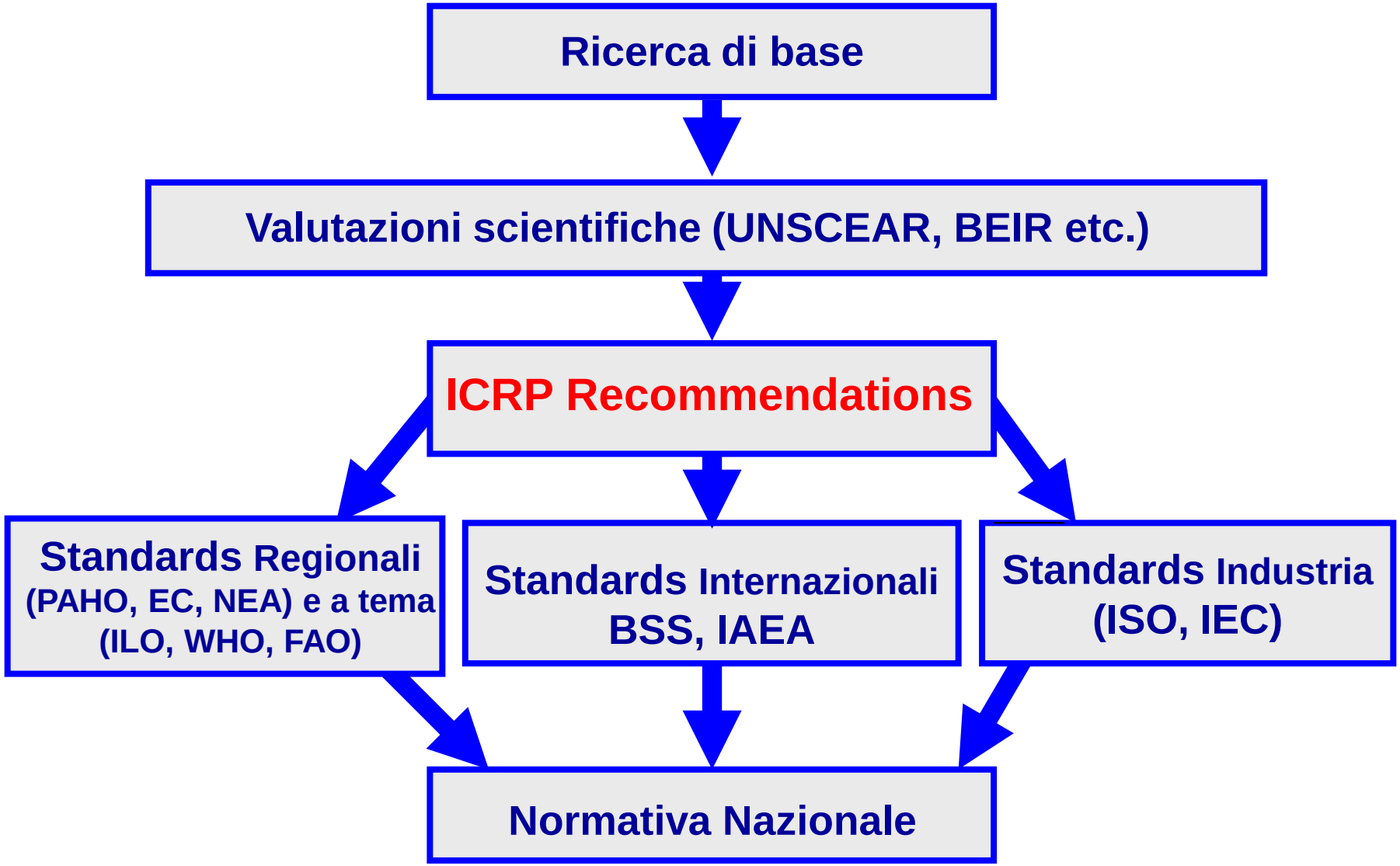


Tissue reactions (Deterministic effects)

- ICRP 41 (1984): *non-stochastic* injury in populations of cells
- ICRP 60 (1991): *deterministic effects*, causally determined by preceding events i.e. the dose
- ICRP 103 (2008): *tissue reactions (deterministic effects)*, subject to biological response modifiers (dose modifying factors 1.1 to 2)
- It is now clear that not all non-cancer responses are the result of cell killing and determined directly by the radiation exposure (**deterministic**) but can arise by a number of tissue responses directly and indirectly due to the radiation (**tissue reactions**)

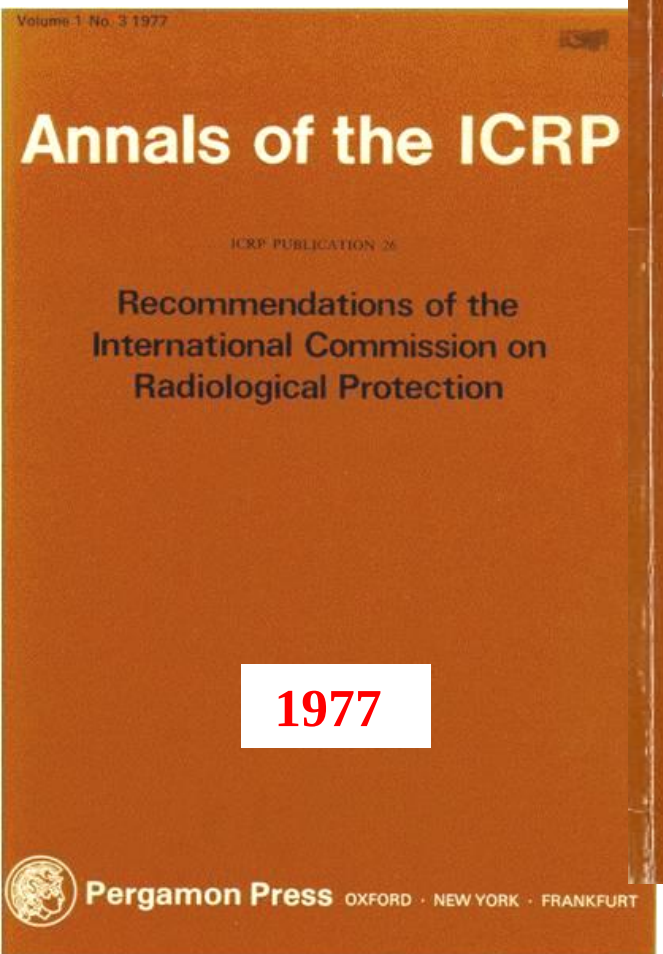
Report Conclusions (2)

- *Third*, the threshold dose values for chronic exposures depend on the exposure duration and the follow-up period after exposure. Differences between these time variables among different studies makes the values more uncertain. The values quoted for both the lens and the circulatory system assume the same incidence of injury irrespective of the acute or chronic nature of the exposure over a working life, with more than 10 years follow-up.

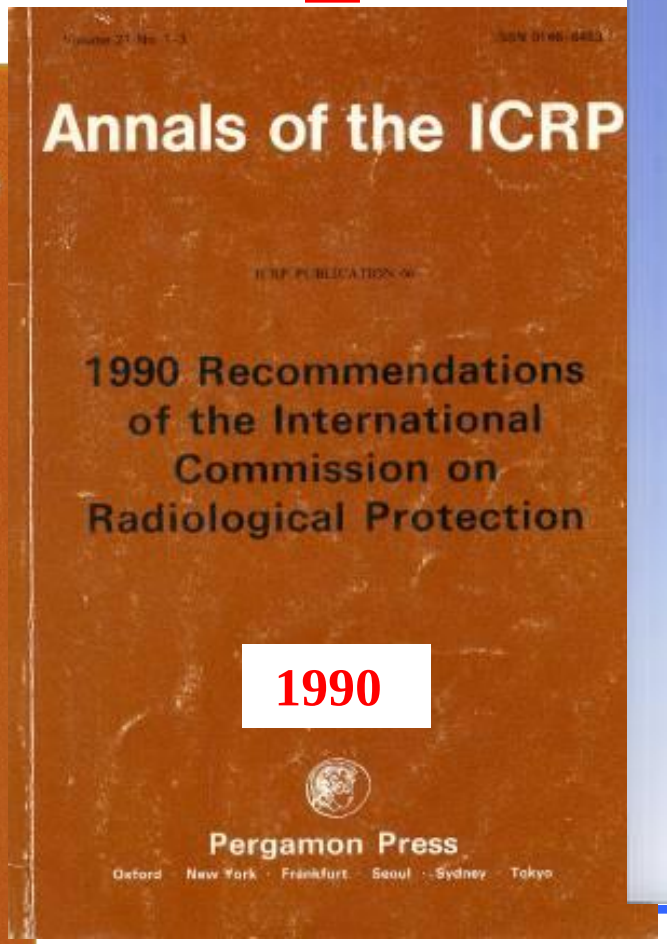

Ricerca di base
Valutazioni scientifiche (UNSCEAR, BEIR etc.)
ICRP Recommendations
Standards Regionali
(PAHO, EC, NEA) e a tema
(ILO, WHO, FAO)
Standards Internazionali
BSS, IAEA
Standards Industria
(ISO, IEC)
Normativa Nazionale

Le revisioni delle BSS sono avvenute in accordo con le Raccomandazioni ICRP

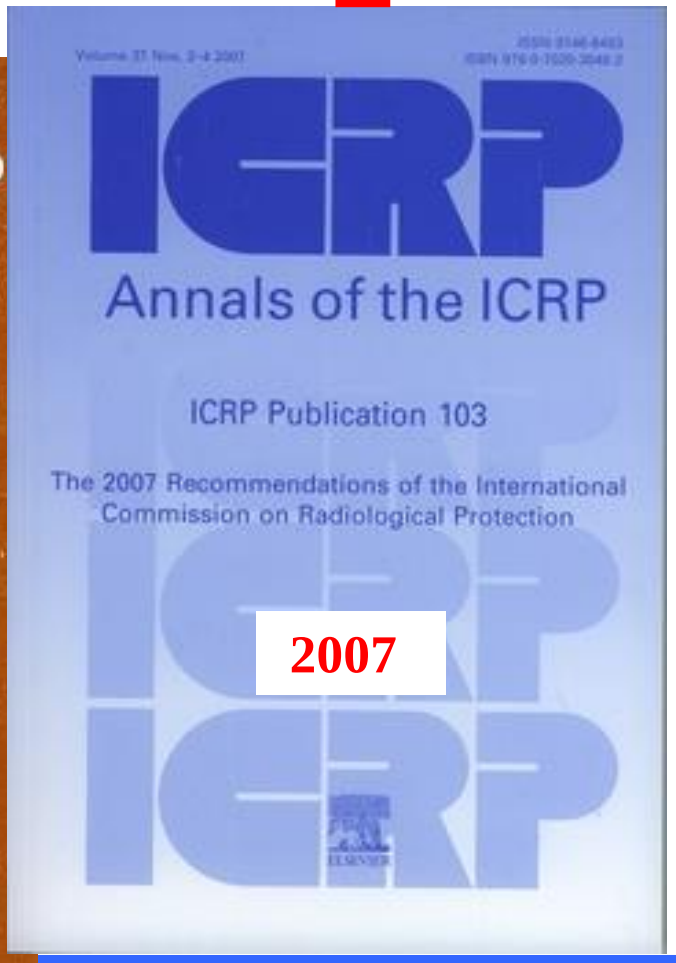
EU BSS 80/836



EU BSS 96/29



NUOVE EU BSS 2013



INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION

ICRP ref 4825-3093-1464

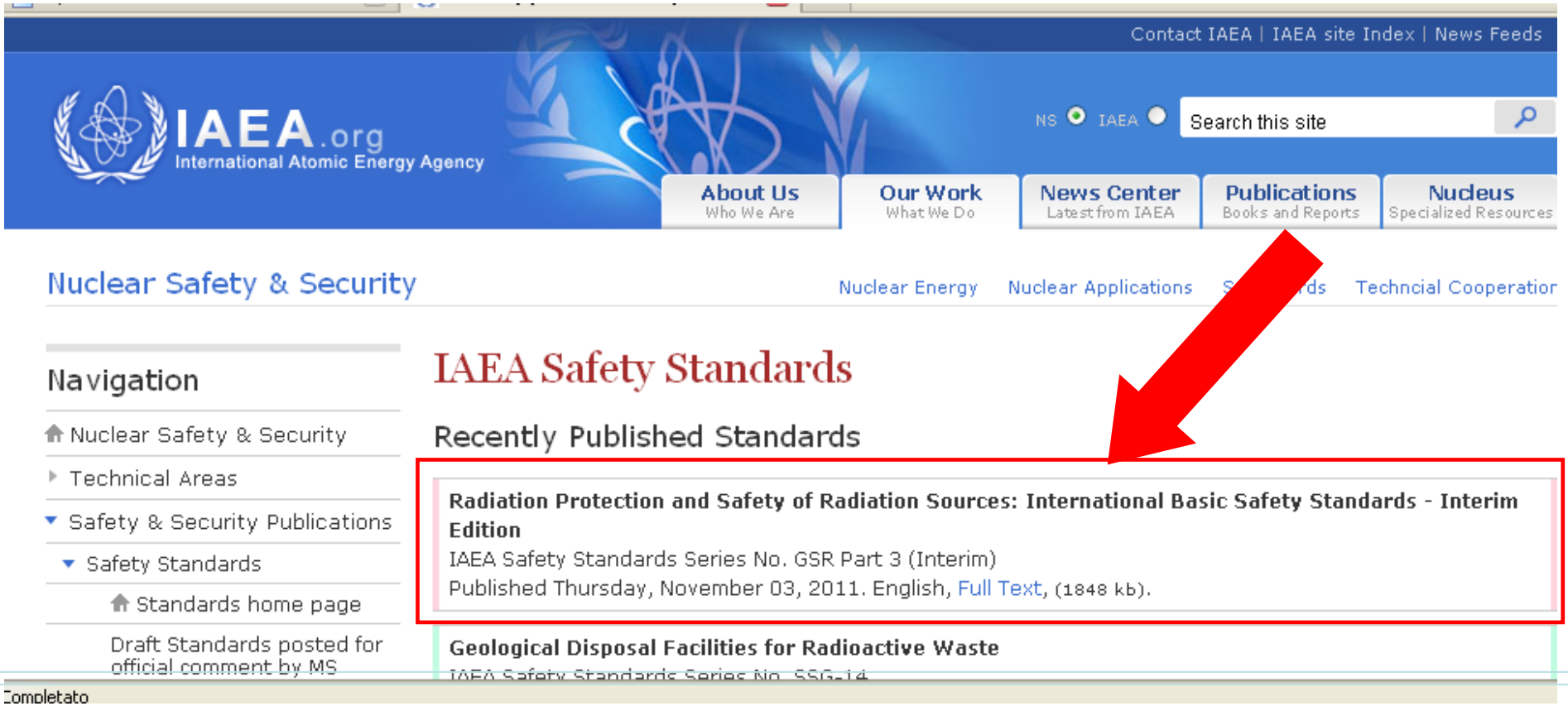
Statement on Tissue Reactions

Approved by the Commission on April 21, 2011

(1) The Commission issued new recommendations on radiological protection in 2007 (ICRP, 2007), which formally replaced the Commission's 1990 Recommendations (ICRP, 1991a). The revised recommendations included consideration of the detriment arising from non-cancer effects of radiation on health. These effects, previously called deterministic effects, are now referred to as tissue reactions because it is increasingly recognised that some of these effects are not determined solely at the time of irradiation but can be modified after radiation exposure. Previously, the Commission had reviewed various aspects of non-cancer health effects of low linear-energy-transfer (LET) ionising radiation in *Publication 41* (ICRP, 1984), high LET radiation in *Publication 58* (ICRP, 1990), the skin in *Publication 59* (ICRP, 1991b), and the skin and the eye in *Publication 85* (ICRP, 2000).

(2) The Commission has now reviewed recent epidemiological evidence suggesting that there are some tissue reaction effects, particularly those with very late manifestation, where threshold doses are or might be lower than previously considered. For the lens of the eye, the threshold in absorbed dose is now considered to be 0.5 Gy.

(3) For occupational exposure in planned exposure situations the Commission now recommends an equivalent dose limit for the lens of the eye of 20 mSv in a year, averaged over defined periods of 5 years, with no single year exceeding 50 mSv.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Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards - Interim Edition
IAEA Safety Standards Series No. GSR Part 3 (Interim)
Published Thursday, November 03, 2011. English, Full Text, (1848 kb).
Geological Disposal Facilities for Radioactive Waste
Completato

IAEA Safety Standards

for protecting people and the environment

Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards

INTERIM EDITION

General Safety Requirements Part 3

No. GSR Part 3 (Interim)

IAEA
International Atomic Energy Agency

Published November 03, 2011

An equivalent dose to lens of the eye of 20 mSv per year averaged over 5 consecutive years . . . . .

Schedule III
DOSE LIMITS FOR PLANNED EXPOSURE SITUATIONS

OCCUPATIONAL EXPOSURE

III-1. For occupational exposure of workers over the age of 18 years, the dose limits are:

(a) An effective dose of 20 mSv per year averaged over five consecutive years[64] (100 mSv in 5 years), and of 50 mSv in any single year;
(b) An equivalent dose to the lens of the eye of 20 mSv per year averaged over 5 consecutive years (100 mSv in 5 years) and of 50 mSv in any single year;
(c) An equivalent dose to the extremities (hands and feet) or the skin[65] of 500 mSv in a year.

Additional restrictions apply to occupational exposure for a female worker who has notified pregnancy or is breast-feeding (para. 3.114).

III-2. For occupational exposure of apprentices of 16 to 18 years of age who are being trained for employment involving radiation and for exposure of students of age 16 to 18 who use sources in the course of their studies, the dose limits are:

(a) An effective dose of 6 mSv in a year;
(b) An equivalent dose to the lens of the eye of 20 mSv in a year;
(c) An equivalent dose to the extremities (hands and feet) or the skin[65] of 150 mSv in a year.

PUBLIC EXPOSURE

III-3. For public exposure, the dose limits are:

(a) An effective dose of 1 mSv in a year;
(b) In special circumstances[66], a higher value of effective dose in a single year could apply, provided that the average effective dose over five consecutive years does not exceed 1 mSv per year;
(c) An equivalent dose to the lens of the eye of 15 mSv in a year;
(d) An equivalent dose to the skin of 50 mSv in a year.

EUROPEAN COMMISSION

Brussels, 29.9.2011
COM(2011) 593 final

2011/0254 (NLE)

Proposal for a

COUNCIL DIRECTIVE

laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation

Draft presented under Article 31 Euratom Treaty for the opinion of the European Economic and Social Committee
{SEC(2011) 1098 final}
{SEC(2011) 1099 final}

… the equivalent dose for the lens of the eye shall be 20 mSv in a year or, where applicable, the same value as specified for the limit on effective dose ;

Article 10

Dose limits for occupational exposure

1. The limit on the effective dose for occupational exposure shall be 20 mSv in any single year. However, in special circumstances or for certain exposure situations specified in national legislation, a higher effective dose of up to 50 mSv per year may be authorised in a single year, provided that the average dose over any five consecutive years does not exceed 20 mSv per year.

For emergency workers a higher effective dose may be authorised, in accordance with Article 52.

2. In addition to limits of effective dose laid down in paragraph 1, the following limits on equivalent dose shall apply:

(a) the limit on the equivalent dose for the lens of the eye shall be 20 mSv in a year or, where applicable, the same value as specified for the limit on effective dose;

(b) the limit on the equivalent dose for the skin shall be 500 mSv in a year;, this limit shall apply to the dose averaged over any area of 1 cm^2, regardless of the area exposed;

(c) the limit on the equivalent dose for the hands, forearms, feet and ankles shall be 500 mSv in a year.

DRAFT REPORT FOR CONSULTATION

ICRP ref 4811-3039-3350
May 5, 2010

Radiological protection education and training for healthcare staff and students

Chairman

Full Mem
Rehani. C

Carmel J. Caruana, Chair

Education and Training Committee
EFOMP

INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION

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Submitted by Carmel J. Caruana Chair, Education and Training Committee, EFOMP
Document Education and Training

Comments of the European Federation of Organizations for Medical Physics (EFOMP) on the ICRP draft report: Radiological Protection Education and Training for Healthcare Staff and Students

INTRODUCTION

This report is an important step forward in the improvement of the optimization of radiation protection of patients and staff. Medical physici
globally expend a lot of energy on researching new techniques and methods for patient dose optimization and reduction of risk to staff.
However, we find in general that not enough curriculum time and resources are allocated to make it possible for us to transfer the knowled

Tempi di ricaduta a livello nazionale ?

			D.P.R. 185 1964
ICRP 26 1977	IAEA BSS 1982	EU BSS 80/836 1980	D.L. 230 1995
ICRP 60 1990	IAEA BSS 1996	EU BSS 96/29 1996	D.L. 241 2000
ICRP 103 2007	IAEA BSS 2014	EU BSS 2013/59 2014	2020

Decreto Legislativo
31 luglio 2020

