Projet de rapport de la CIPR sur la dose efficace

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1. Dose efficace en tant que « indicateur approximatif du risque possible »

2. Application à la radioprotection médicale

Construction du détriment

(20) The data provided in *Publication 103* (ICRP, 2007a) for the calculation of nominal risk coefficients, relative detriment and tissue weighting factors, for use in the calculation and application of effective dose, **do not consider age, sex and population related differences in risk**, except for the distinction between the whole population (0–84 years at exposure) and the working age population (18-64 years at exposure).

Lien direct entre dose efficace et détriment

[Rapport du TG79]

Construction du détriment

Nominal Cancer Risks and Detriment for uniform whole-body exposure to gamma rays for the whole population (ICRP *Publication 103*, 2007)

Tissue	Nominal Risk Coefficient (cases per 10,000 persons per Gy)	Lethality fraction	Nominal risk adjusted for lethality and quality of life	Relative cancer free life lost	Detriment (relating to column 1)	Relative detriment[+]
Oesophagus	15	0.93	15.1	0.87	13.1	0.023
Stomach	79	0.83	77.0	0.88	67.7	0.118
Colon	65	0.48	49.4	0.97	47.9	0.083
Liver	30	0.95	30.2	0.88	26.6	0.046
Lung	114	0.89	112.9	0.80	90.3	0.157
Bone surface	7	0.45	5.1	1.00	5.1	0.009
Skin	1000	0.002	4.0	1.00	4.0	0.139
Breast	112	0.29	61.9	1.29	79.8	0.017
Ovary	11	0.57	8.8	1.12	9.9	0.029
Bladder	43	0.29	23.5	0.71	16.7	0.022
Thyroid	33	0.07	9.8	1.29	12.7	0.015
Bone Marrow	42	0.67	37.7	1.63	61.5	0.107
Other Solid	144	0.49	110.2	1.03	113.5	0.198
Gonads (Hereditary)	20	0.80	19.3	1.32	25.4	0.044
Total	1715		565		574	1.000

Construction du risque nominal

Estimation du risque vie entière attribuable à une exposition donnée aux rayonnements ionisants, en nombre de cas pour 100 000 personnes

Nécessite

- Données de référence : taux de base, fonction de survie, pyramide d'âge – Population Euro-Américaine et Population Asiatique
- Modèle de risque : relation dose-risque, avec effet modifiant de l'âge, suppose une relation linéaire sans seuil, applique un coefficient de réduction de pente de 2 (DDREF) - dérivé de la cohorte des survivants de Hiroshima et Nagasaki

Application CIPR

- Calculé pour 14 organes/types de cancer
- Moyenné entre les hommes et les femmes
- Moyenné sur l'âge à l'exposition de 0 et 84 ans
- Cumulé jusqu'à l'âge 89 ans (90^{e} anniversaire)

Variation du risque de cancer vie entière par Gy avec l'âge

Table 2.4. Lifetime attributable risks of cancer incidence per absorbed dose (cases per 100 per Gy) from uniform external exposure to gamma rays for the ICRP (2007a) Euro-American composite population.

	Age at exposure (y)									
Organ	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99
Females										
Breast	6.7	4.1	2.5	1.5	0.8	0.4	0.2	0.07	0.02	0.0
Lung	1.5	1.6	1.7	1.8	1.9	1.9	1.6	1.1	0.5	0.06
Stomach	1.7	1.3	1.0	0.7	0.5	0.3	0.2	0.1	0.05	0.0
Colon	0.8	0.7	0.5	0.4	0.3	0.2	0.1	0.08	0.03	0.0
RBM	0.5	0.5	0.5	0.4	0.5	0.3	0.2	0.1	0.04	0.01
Bladder	0.8	0.7	0.6	0.5	0.4	0.4	0.3	0.2	0.1	0.01
Liver	0.3	0.2	0.2	0.1	0.09	0.06	0.04	0.02	0.01	0.0
Thyroid	1.9	0.8	0.3	0.1	0.04	0.01	0.0	0.0	0.0	0.0
Oesophagus	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.03
Ovary	0.6	0.4	0.3	0.2	0.2	0.1	0.06	0.03	0.01	0.0
Other	3.7	2.5	1.7	1.2	0.8	0.5	0.3	0.1	0.05	0.0
All cancers	**18.5**	**13.0**	**9.4**	**7.1**	**5.7**	**4.4**	**3.2**	**2.1**	**1.0**	**0.1**

[Rapport du TG79]

Variation du risque de cancer vie entière par Gy avec l'âge par site de cancer

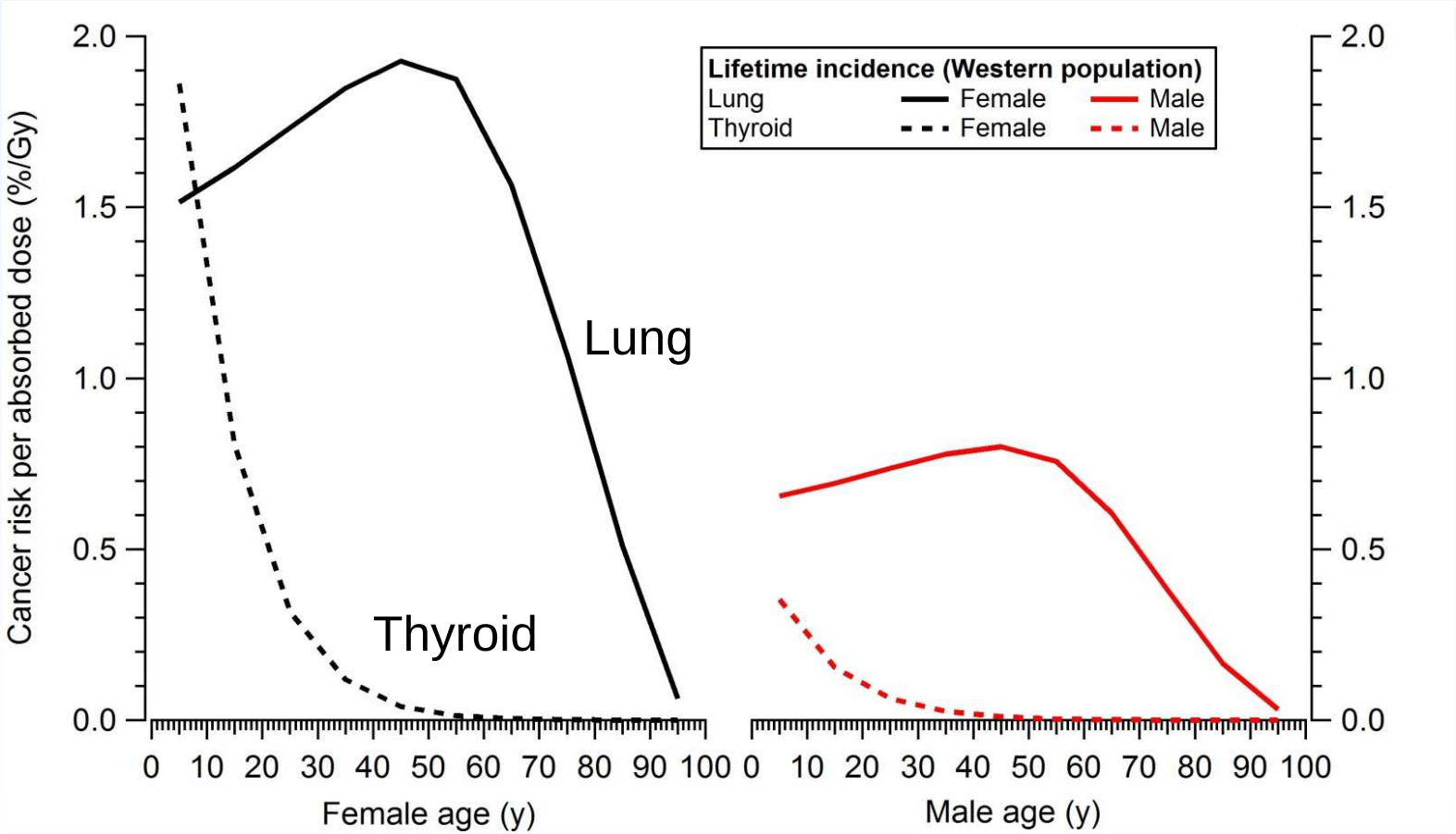
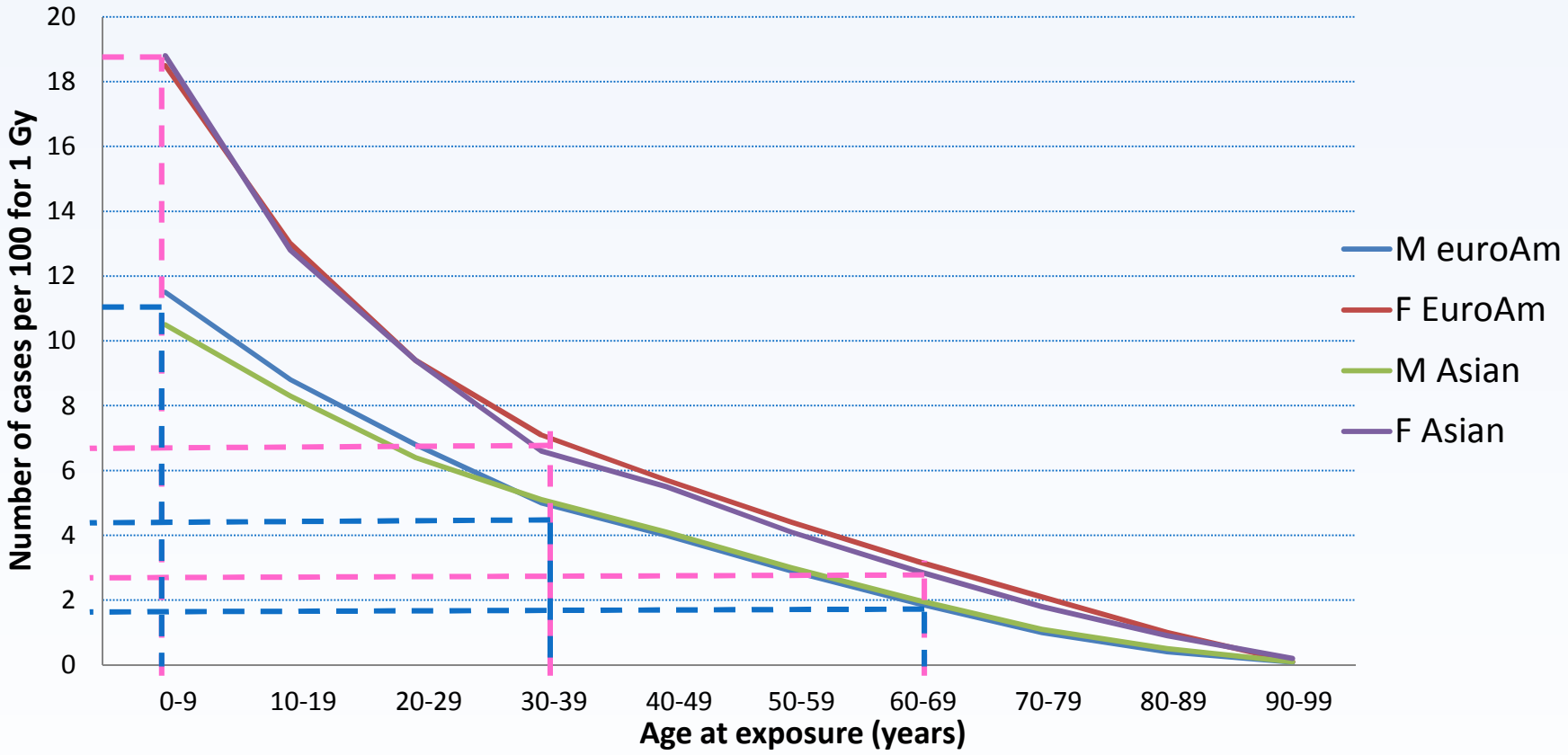


Fig. 2.1. Lifetime attributable risks of cancer incidence per absorbed dose (cases per 100 per Gy; % / Gy) from uniform external exposure to gamma rays for the ICRP (2007a) Euro-American composite population for lung and thyroid cancer (from Table 2.4).

[Rapport du TG79]

Variation du risque vie entière tous-cancers par Gy avec l'âge



"Considering all cancer sites combined, lifetime risks compared with those for the 30-39 y age-group were estimated to be greater by a factor of about two to three for exposures of young children, aged 0-9 y, and less by a factor of two to three for exposures of older adults aged 60-69 y"

Dose efficace en tant qu'indicateur approximatif du risque possible

(129) "Bearing in mind the uncertainties associated with risk projection to low doses or dose-rates, ***E*** **may be considered as an approximate indicator of possible risk**, with the additional consideration of variation in risk with age, sex and population group."

(132) "The use of **effective dose as an approximate indicator of stochastic risks can be reasonably extended beyond medical applications to, for example, consideration of protection options for accidental exposures of workers and members of the public**. The same caveats apply, including the uncertainties in inferring risks at low doses.

[Rapport du TG79]

Dose efficace en tant qu'indicateur approximatif du risque possible

(129) "It is emphasized that use of *E* as an approximate measure of possible risk is **not a substitute for risk analysis** using best estimates of organ/tissue doses, appropriate information on the relative effectiveness of different radiation types, and age-, sex- and population-specific risk factors applying to the organs/tissues at risk, with consideration of uncertainties."

(132) In all cases, exposures that are largely limited to a single organ/tissue **should be assessed using organ/tissue dose and organ/tissue-specific risk coefficients**, as for example, in exposures of the thyroid following intakes of radioactive iodine."

[Rapport du TG79]

Sommaire

1. Dose efficace en tant que « indicateur approximatif du risque possible »

2. Application à la radioprotection médicale

Doses efficaces pour comparer des examens usuels

Valeurs typiques (mSv) chez l'adulte dans 3 pays

Examen	UK	USA	Russie
Radiologie conventionnelle			
Thorax de face (PA)	0,014	0,03	0,1
Thorax de profil	0,038	0,07	0,18
Rachis lombaire de face (AP)	0,39	2,0	0,6
Rachis lombaire de profil	0,21	2,0	0,6
Abdomen de face (AP)	0,43	0,7	1,0
Bassin de face (AP)	0,28	1,25	0,7
Radiologie interventionnelle			
Coronarographie	3,9	15	15
Angiographie fémorale	2,3	7	5-10
Scanographie			
Tête	1,8	2,1	1,8
Thorax	14	11	6,3
Abdomen	16		9
Abdomen + pelvis	13	17	
Thorax + abdomen + pelvis	19	29	25
Médecine nucléaire			
Scintigraphie osseuse (^{99m}Tc)	3	5	3
TEP (^{18}F FDG)	7	10	5

Tableau 5.1 [Rapport du TG79]

Calcul du « risque efficace »

Cette comparaison entre pratiques basée sur la dose efficace masque les différences dans les organes exposés

➡ **Calcul du risque efficace** (Brenner 2012)

Pour un examen donnée:

- Estimer la dose absorbée à chaque organe exposé telle que la dose efficace soit égale à 1 Sv
- Estimer le risque cumulé de cancer correspondant à chaque organe
- Calculer la somme de ces risques vie entière

List des applications médicales

18 examens médicaux diagnostiques classiques utilisant des rayonnements X (radiographie et fluoroscopie)

Doses basées sur des données anglaises (d'après Wall et al, PHE 2011)

Radiologie conventionnelle

- Tête (AP+PA+Lat)
- Rachis cervical (AP+Lat)
- Thorax (PA)
- Rachis thoracique (AP+Lat)
- Abdomen (AP)
- Pelvis (AP)
- Rachis lombaire (AP+Lat)

Radiologie interventionnelle

- Coronarographie
- Angiographie fémorale

Produit de contraste

- Urographie intraveineuse
- Gorgée barytée
- Transit baryté
- Lavement baryté

Scanographie

- Tête
- Thorax
- Abdomen
- Abdomen + pelvis
- Thorax + abdomen + pelvis

AP: Antéro-postérieure; PA: postéro-antérieure; Lat: latérale

[Rapport du TG79]

Risque de cancer par Sv pour différentes applications médicales

Table 5.3. Total lifetime risks of cancer incidence (cases per 100) per Sv effective dose as a function of age at exposure and sex for a range of x-ray examinations, calculated using risk data for the ICRP Euro-American composite population (based on Wall et al., 2011).

		Age at exposure (y)									
Examination	Sex	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99
Coronary	M	10	8	7	6	5	4	3	2	0.9	0.2
angiography	F	13	11	10	10	10	9	7	5	3	0.3
Femoral	M	14	11	8	6	5	3	2	0.9	0.4	0.1
angiography	F	11	8	7	5	4	3	2	1	0.5	0.1
CT head	M	22	15	11	7	5	3	2	0.8	0.3	0.1
	F	17	12	8	6	4	3	2	0.9	0.4	0
CT chest	M	9	7	6	4	4	3	2	1	0.5	0.1
	F	22	15	11	9	7	6	5	3	1	0.2
CT abdomen	M	13	10	8	5	4	3	2	0.8	0.3	0
	F	13	10	7	6	4	3	2	1	0.5	0.1
CT abdomen +	M	14	11	9	6	5	3	2	0.9	0.3	0.1
pelvis	F	13	10	8	6	5	3	2	1	0.6	0.1
CT chest +	M	11	8	7	5	4	3	2	1	0.5	0.1
abdo + pelvis	F	18	13	10	8	6	5	4	2	1	0.1

[Rapport du TG79]

Risque de cancer par Sv pour les applications médicales

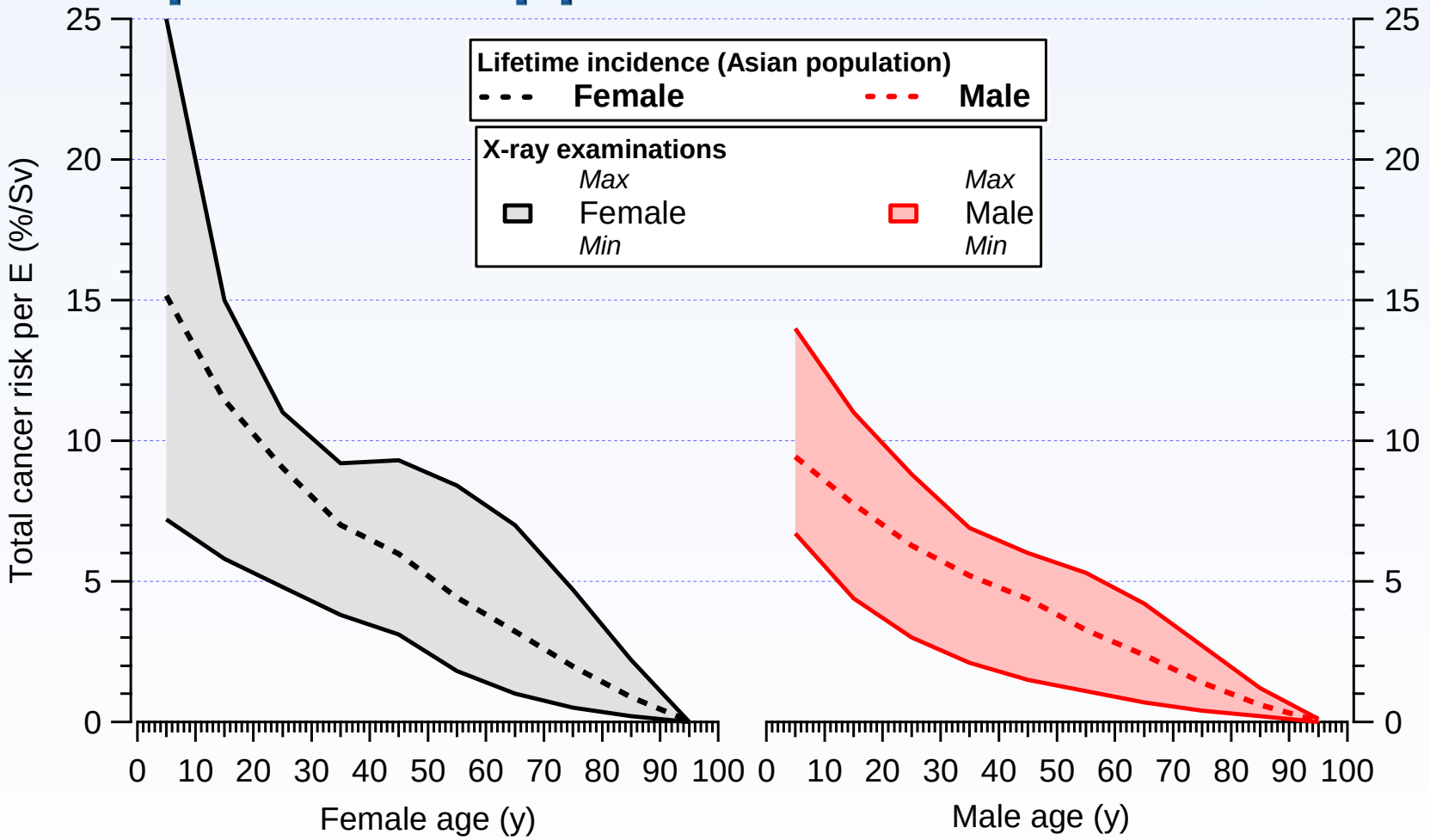


Fig. 5.1. Total lifetime risk of cancer incidence per unit effective dose (cases per 100 per Sv: %/Sv) as a function of age at exposure and sex for a range of x-ray examinations (Table 5.4) and for uniform whole body exposure of a composite Asian population (Table 2.5).

[Rapport du TG79]

Risque de cancer par Sv pour les applications médicales

(117) …**For most procedures, the estimates of lifetime risk of cancer incidence per Sv are within about ± 50% of those for uniform whole-body irradiation** for the particular age and sex, noting that the cancer types involved will differ between procedures.

(118) …it can be concluded that when considering most x-ray examinations, **lifetime risks of cancer incidence per Sv may be around twice as great for the 0-9 y age at exposure group than the 30-39y group**. For patients exposed in their 60s, the estimated lifetime risks are about half those for patients in their 30s, falling to less than one-third for patients in their 70s and about one-tenth for those in their 80s.

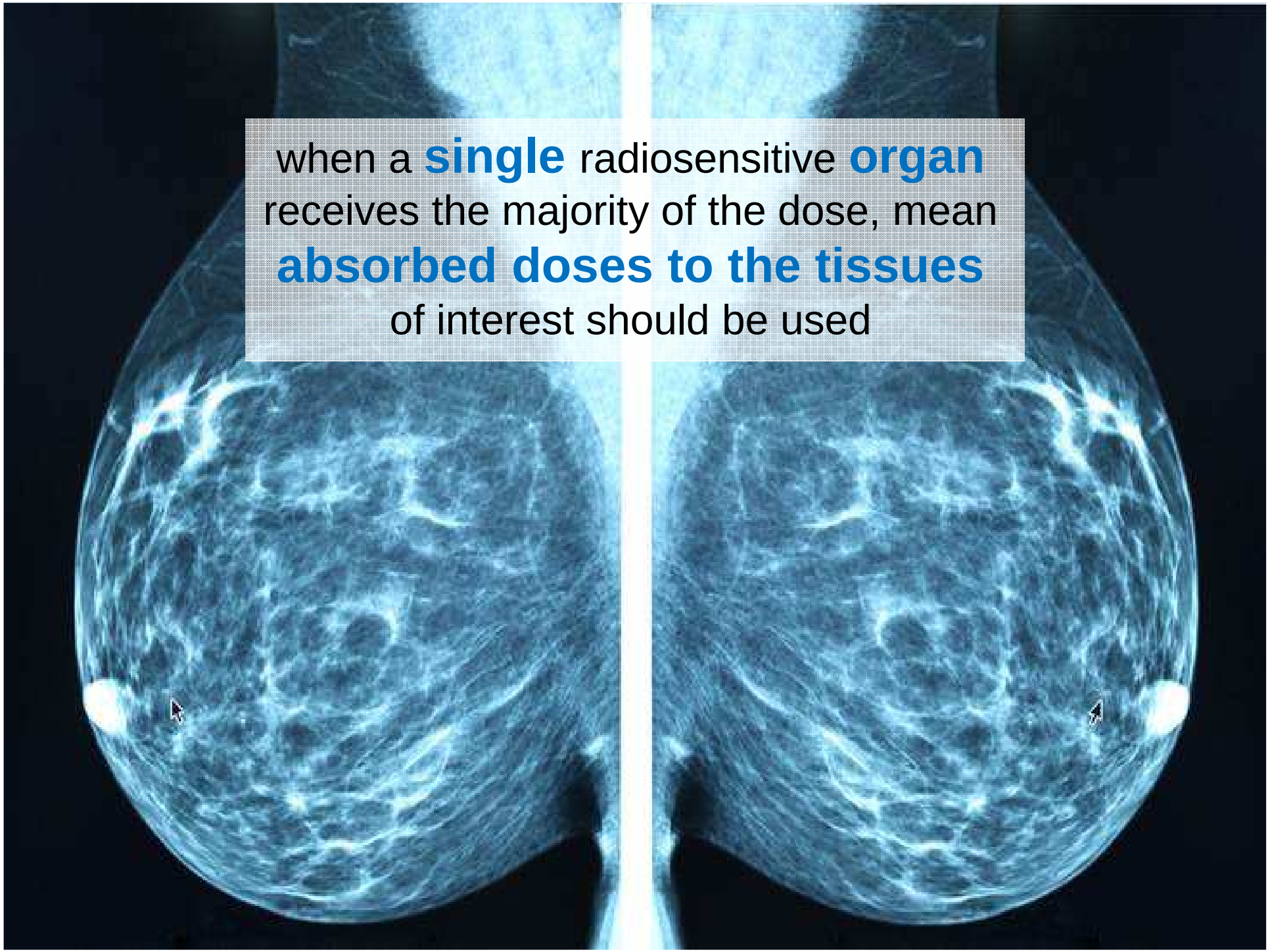
(118) …Bearing in mind the substantial uncertainties associated with projections of low dose risk, **it is considered reasonable to reflect such variations in possible risk per Sv effective dose in conveying information to clinicians and patients**.

[Rapport du TG79]

Dose efficace en tant qu'indicateur approximatif du risque possible en radioprotection médicale

(129) E is in widespread use in medical practice as an approximate indicator of risk. It is made clear in this report that while doses incurred at low levels of exposure may be measured or assessed with reasonable accuracy, the associated risks are uncertain. However, bearing in mind the uncertainties associated with risk projection to low doses/dose-rates, **E may be considered as an approximate indicator of possible risk, with the additional consideration of variation in risk with age, sex and population group. In the majority of situations, simple qualitative descriptors of the possible risk associated with effective dose will be sufficient to inform judgements.**

[Rapport du TG79]


when a **single** radiosensitive **organ**
receives the majority of the dose, mean
absorbed doses to the tissues
of interest should be used

Sommaire

Conclusion générale

Conclusions et perspectives

Points forts du rapport

- Clarification de l'utilisation du concept de dose efficace
- Simplification par l'abandon de la dose équivalente
- Prise en compte des variations du risque radioinduit de cancer avec l'âge
- Objectif d'application pratique en radioprotection médicale
- E utilisable en première instance comme indicateur approximatif de risque pour une procédure médicale, mais ne remplace pas une évaluation du risque basée sur la dose absorbée aux organes exposés

Conclusions et perspectives

Perspectives ouvertes par le rapport

- Améliorer l'évaluation du risque radioinduit associé à une exposition durant l'enfance
- Améliorer l'adéquation entre la contribution de chaque organe au risque global et les W_T
- Clarifier ce qui « basé sur la science » et ce qui relève de l'avis d'expert dans le système de radioprotection
- Clarifier la distinction entre évaluation quantitative des risques et indicateur de risque en radioprotection

Consultation

Rapport disponible pour consultation publique sur

www.ICRP.org

Commentaires attendus jusqu'au 3 Aout 2018

Merci à Eric Blanchardon, Enora Cléro et John Harrison pour leur aide dans la préparation de cette présentation

Merci de votre attention

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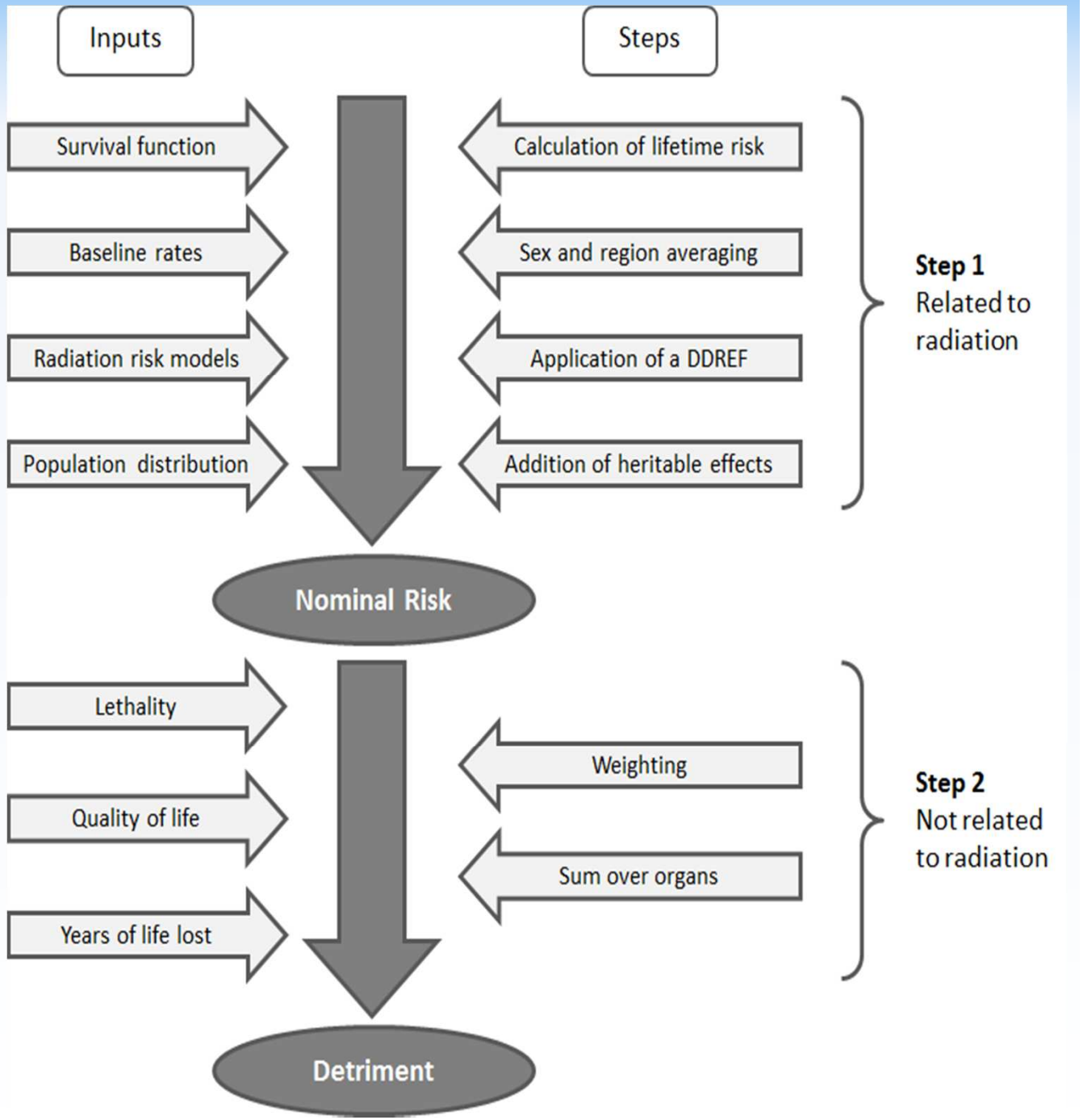
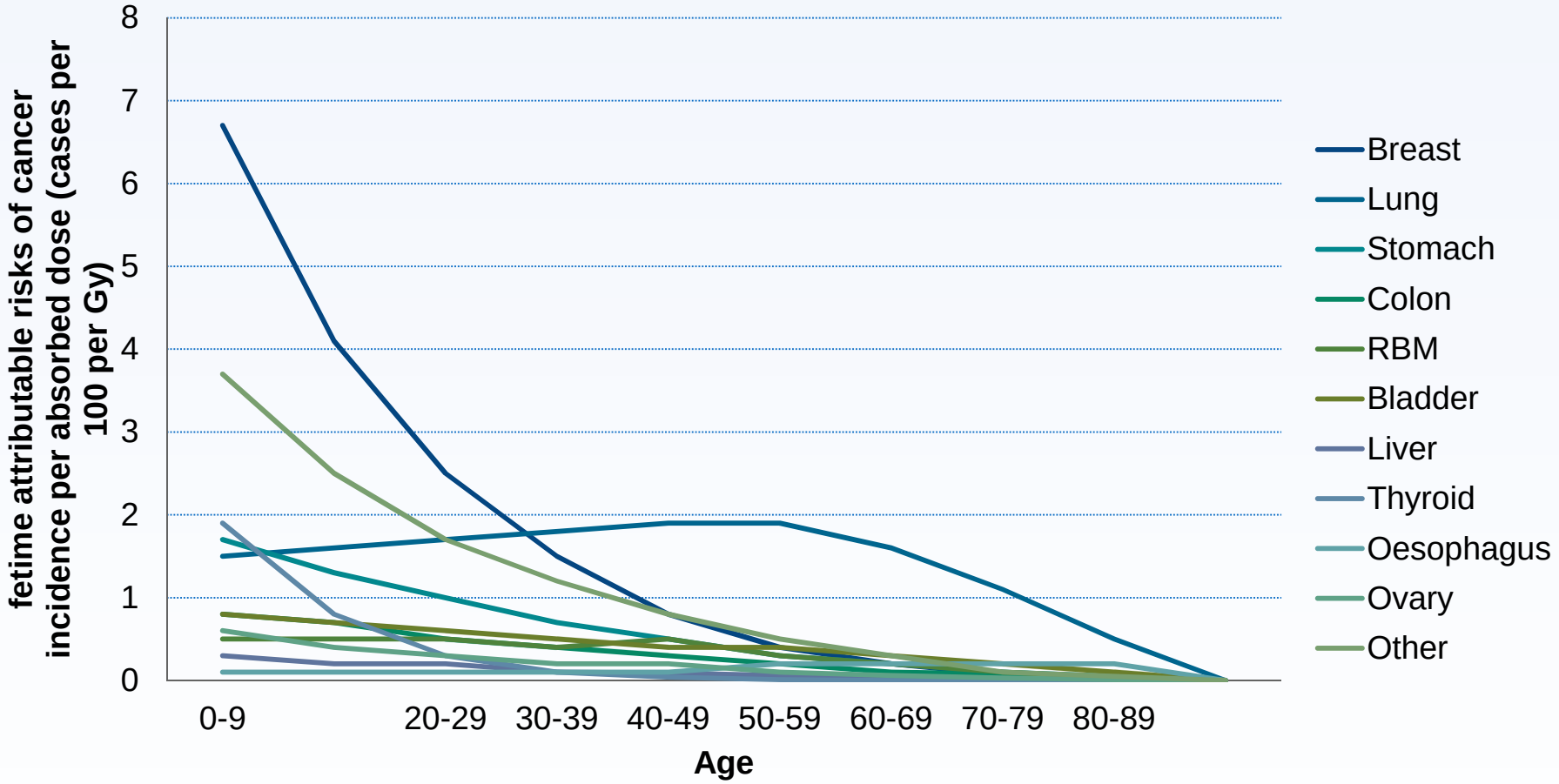
Construction du détriment



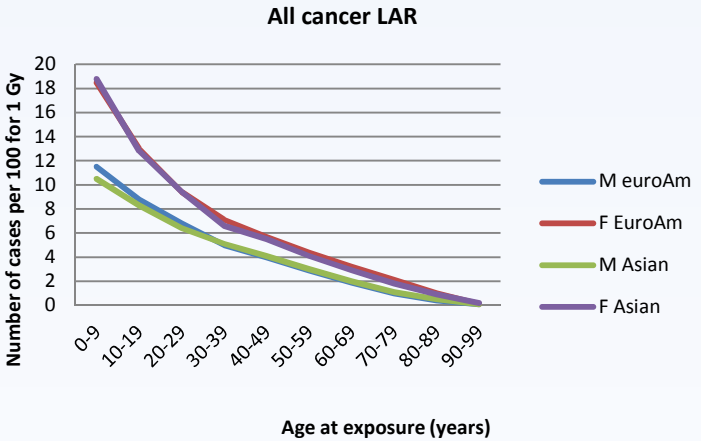
Variation du risque de cancer vie entière avec l'âge par site de cancer



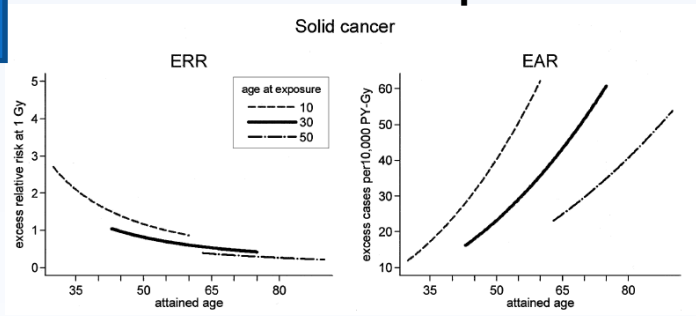
Lifetime attributable risks of cancer incidence per absorbed dose (cases per 100 per Gy) from uniform external exposure to gamma rays (ICRP Female Euro-American population).

[Rapport du TG79]

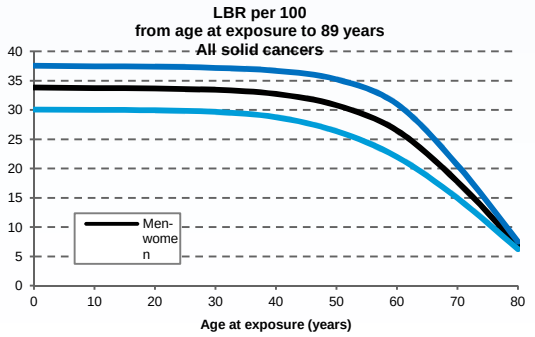
Variation du risque de cancer vie entière avec l'âge



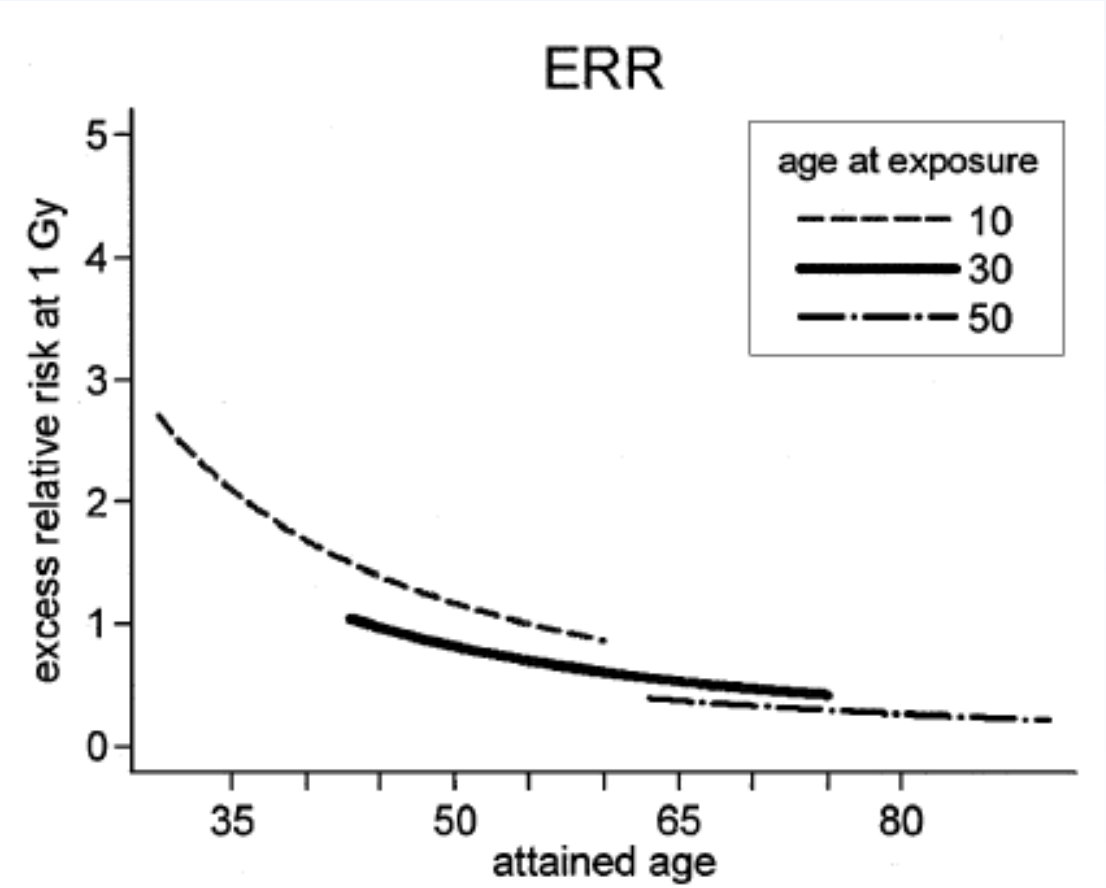
Modèle de risque



Risque vie entière de base



Modèle de risque : variation de l'ERR/Gy avec l'âge

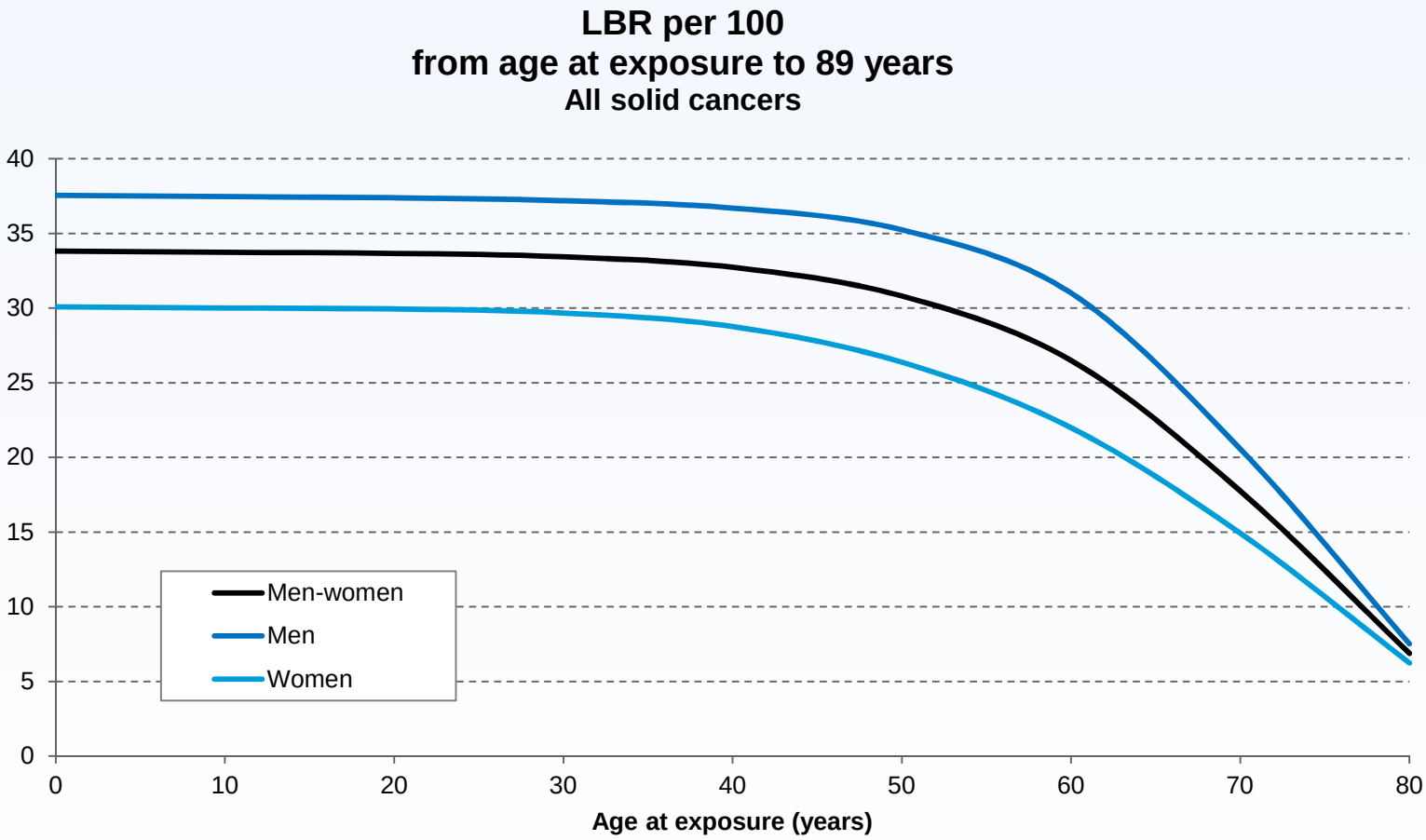


Excès de risque relatif par Gy pour les cancers solides, en fonction de l'âge atteint et pour 3 catégories d'âge à l'exposition, moyenné sur les 2 sexes

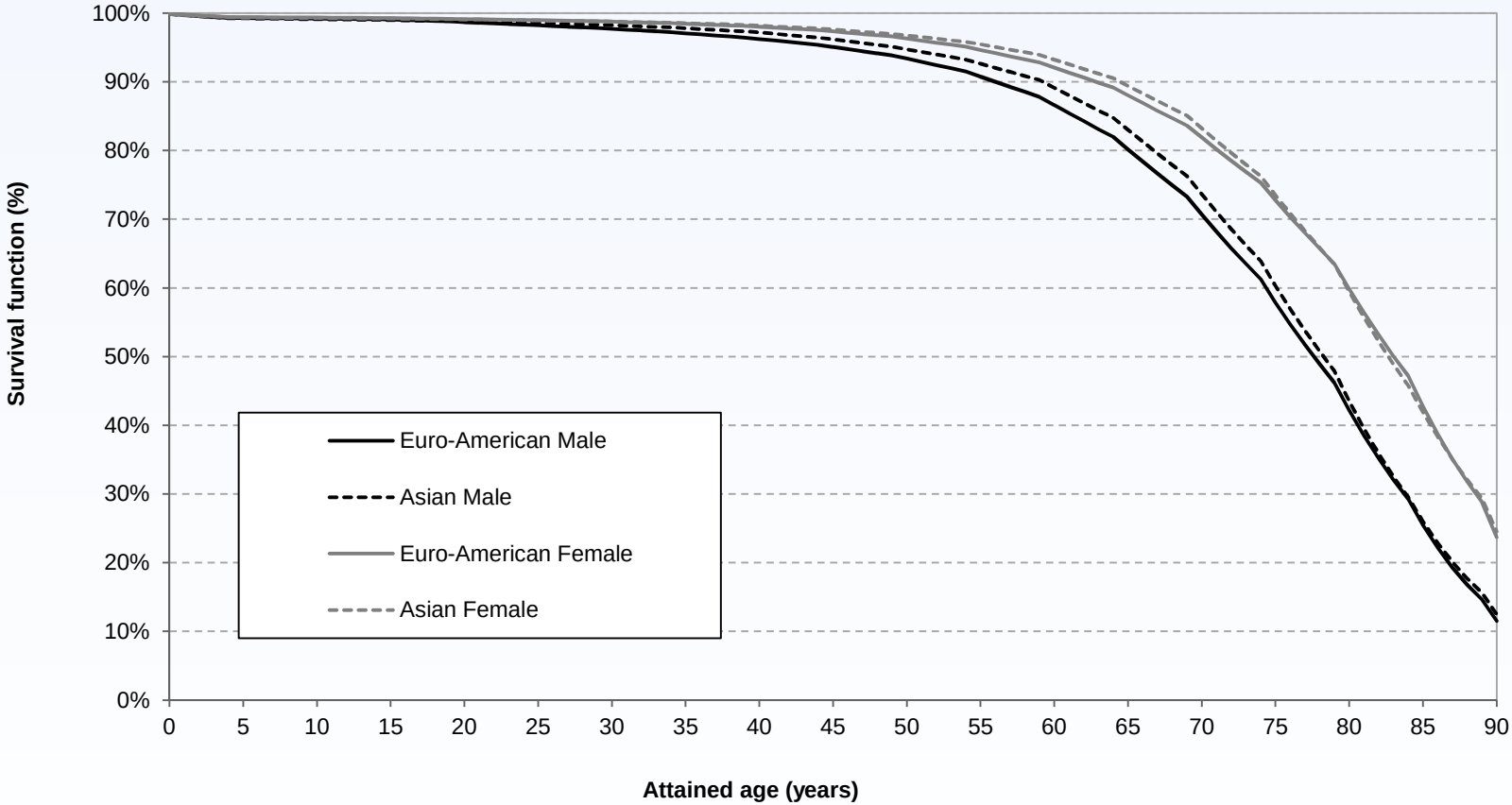
(Cohorte des survivants des bombardements atomiques de Hiroshima et Nagasaki, Incidence 1958-1998)

[Preston et al. rad Res 2007]

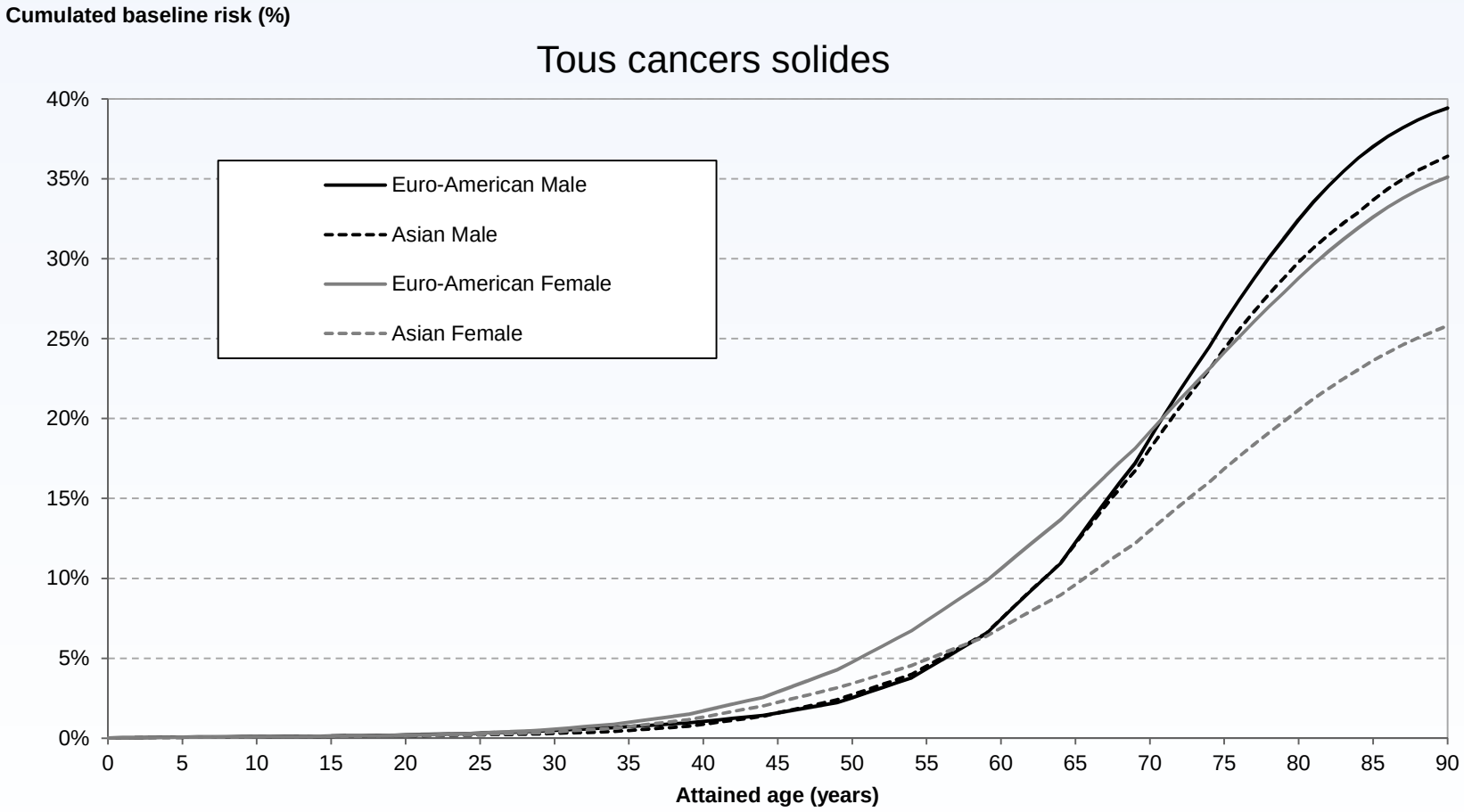
Risque vie entière de base: variation avec l'âge



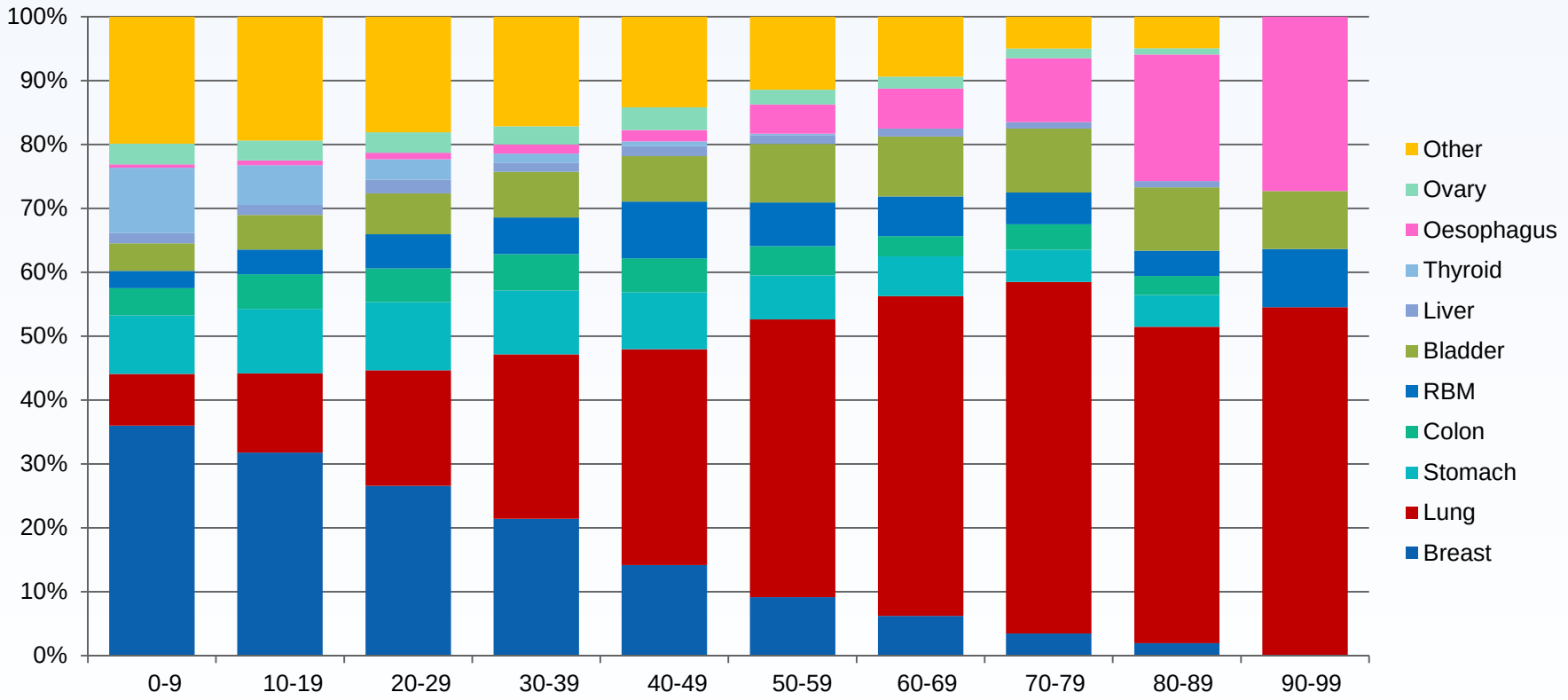
Fonction de survie: variation avec l'âge



Taux de base cumulé: variation avec l'âge



Contribution des différents organes au risque cumulé global par Gy : variation avec l'âge



Dose efficace en tant qu'indicateur approximatif du risque possible

(131) "It should be recognised that these data are subject to substantial uncertainties inherent in their derivation and application to low dose radiation exposures. With this important caveat, it can be concluded that when considering most x-ray examinations, **lifetime risk of cancer incidence per Sv may be around twice as great for the 0-9 y age at exposure group than for the 30-39y group**. For patients in their 60s, the lifetime risks from most examinations are estimated to be about half those for patients in their 30s, falling to less than one-third for patients in their 70s and about one-tenth for those in their 80s. "

[Rapport du TG79]

Risque de cancer par Sv pour différentes applications médicales

Table 5.3. Total lifetime risks of cancer incidence (cases per 100) per Sv effective dose as a function of age at exposure and sex for a range of x-ray examinations, calculated using risk data for the ICRP Euro-American composite population (based on Wall et al., 2011).

		Age at exposure (y)									
Examination	Sex	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99
Head	M	21	14	10	6	4	3	1	0.6	0.2	0
(AP+PA+Lat)	F	24	14	9	6	4	2	1	0.7	0.3	0
Cervical spine	M	13	8	5	3	2	1	0.6	0.3	0.1	0
(AP+Lat)	F	38	18	8	4	2	1	0.9	0.5	0.2	0
Chest	M	10	8	7	5	5	4	3	2	0.7	0.1
(PA)	F	16	13	11	9	9	8	6	4	2	0.3
Thoracic spine	M	9	7	6	4	4	3	2	1	0.6	0.1
(AP+Lat)	F	23	16	12	9	8	7	5	3	2	0.2
Abdomen	M	14	11	9	6	5	3	2	1	0.4	0.1
(AP)	F	13	10	8	6	5	4	2	1	0.7	0.1
Pelvis	M	12	9	8	6	4	3	2	1	0.4	0.1
(AP)	F	10	8	6	5	4	3	2	1	0.6	0.1
Lumbar spine	M	13	10	8	6	4	3	2	0.8	0.3	0.1
(AP+Lat)	F	13	10	7	6	4	3	2	1	0.6	0.1

[Rapport du TG79]

Dose efficace en tant qu'indicateur approximatif du risque possible en radioprotection médicale

(130) *E* can be used in medical applications to:

- **compare doses from different diagnostic and interventional imaging modalities** that give different spatial distributions of radiation within the body;
- provide a **generic indicator for classifying different types of medical procedure into broad risk categorie**s for the purpose of risk communication;
- **informing decisions on justification** of patient diagnostic and interventional procedures; planning requirements for research studies;
- and, **initial evaluation of unintended exposures** or overexposures of patients.

However, for comparisons of doses from the same procedure in different facilities and for setting diagnostic reference levels, measurable dose quantities are preferable.

[Rapport du TG79]