Effective Dose and Risk Assessment

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Task Group 79 : Use of Effective Dose as a Risk-related Radiological Protection Quantity

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Issues

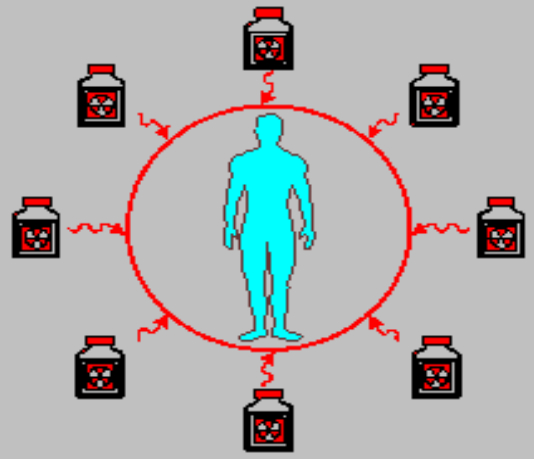
- Equivalent dose and Effective dose, *E*
- *E* for children and fetus
- *E* as a measure of risk

Constraints, reference levels, limits

Protection of workers and public primarily using constraints and reference levels applying to doses from a single source

From a single source in normal, emergency, or existing controllable situations by

Constraints / reference levels



From all regulated sources in normal situations by

Limits

Effective Dose

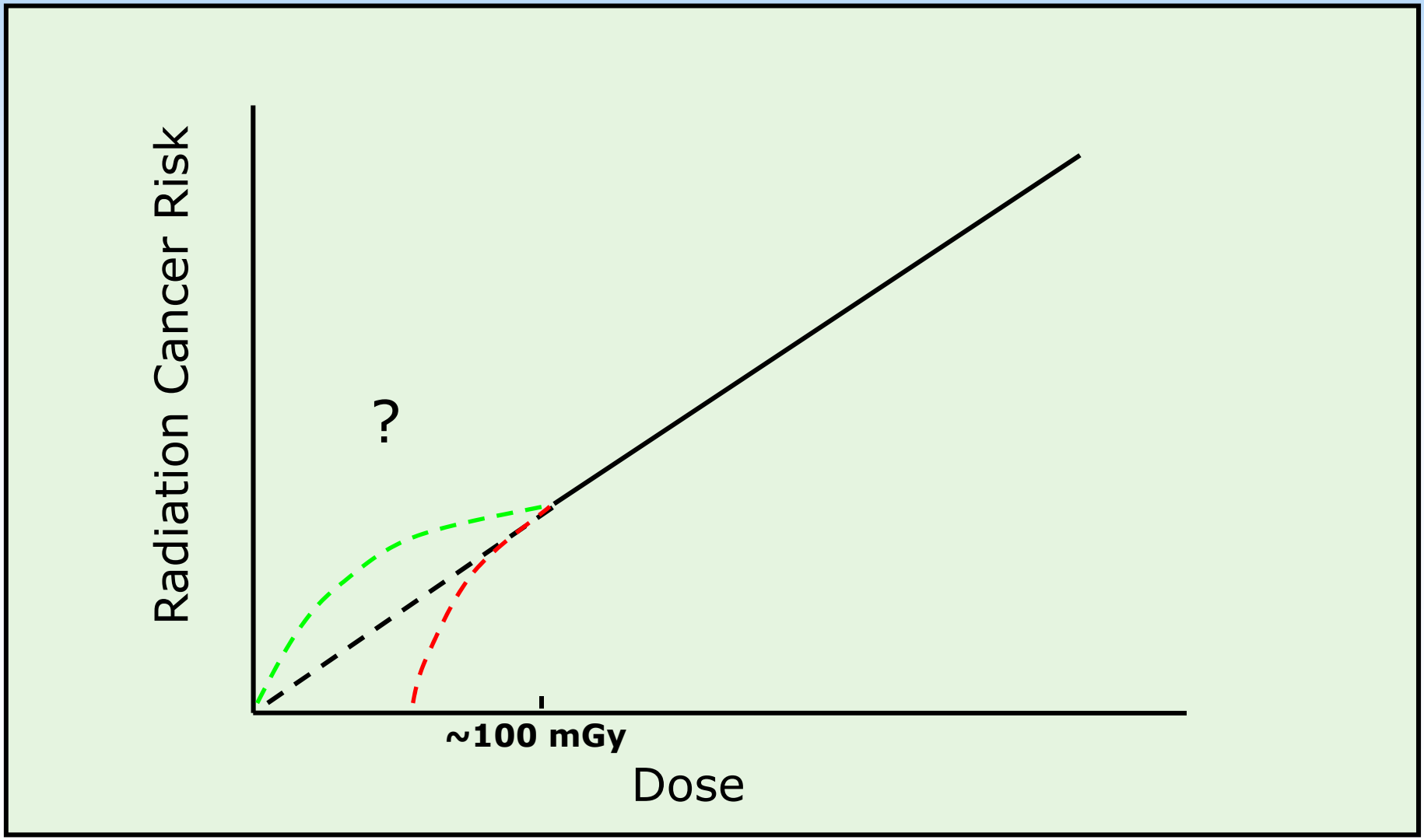
- Enables the summation of all radiation exposures by risk adjustment using simplified weighting factors
- Applies to sex-averaged reference persons, and relates to nominal risk coefficients for uniform external low LET radiation exposure
- Applied without uncertainties, assumes:

  Linear Non-Threshold (LNT) dose-response,

  Chronic = acute

  Internal = external

Cancer incidence



Life-time risk for Euro-American population (% per Gy)

Cancer site	Age at exposure, years					
	Males			Females		
	0-9	20-29	60-69	0-9	20-29	60-69
Breast	-	-	-	4.9	2.2	0.2
Colon	1.5	1.0	0.3	0.7	0.5	0.1
Liver	0.6	0.3	0.1	0.2	0.2	0.03
Lung	0.7	0.7	0.6	1.4	1.6	1.4
Thyroid	0.2	0.1	0	0.9	0.3	0.01
Leukaemia	1.1	0.8	0.5	0.5	0.5	0.3
All cancers	10	6.2	2.2	14	8.5	3.1

Stochastic detriment x 10^{-2} per Sv

Publication 60 (1991)

	Cancer	Hereditary	Total
Worker	4.8	0.8	**5.6**
Public	6.0	1.3	**7.3**

Publication 103 (2007)

Worker	4.1	0.1	**4.2**
Public	5.5	0.2	**5.7**

Equivalent and effective dose

1. **Absorbed dose $D_{T,R}$** in human tissues/organs T, (averaged organ/tissue absorbed dose) **Gy**

2. **Equivalent dose** in tissues/organs, **Sv**

   $H_T = \sum_R w_R D_{T,R}$ w_R **: radiation weighting factor**

3. **Effective dose**, **Sv**

   $E = \sum_T w_T H_T$ w_T **: tissue weighting factor**

Proposal

Consider discontinuing use of Equivalent Dose as a separate protection quantity

- Avoids confusion between equivalent dose and effective dose. Eg. iodine-131, E = 40 mSv, thyroid dose = 1 Sv.
- Avoids confusion between equivalent dose and dose equivalent, Sv, the operational quantity used as a measure of effective dose for external sources
- **Equivalent dose, Sv, currently used to set limits to prevent deterministic effects:** eye lens, skin, hands & feet; the more appropriate quantity is absorbed dose, Gy

ICRP Effective Dose Coefficients

Internal: Sv per Bq intake

External: Sv per fluence or air kerma

- Workers
- Public : Newborn, 1, 5, 10 and 15 y old children, adults
- Radionuclide intakes by pregnant and breast-feeding woman : doses to the fetus and infant

Tissue weighting factors

- *ICRP 60*

0.01	bone surface, skin
0.05	bladder, breast, liver, oesophagus, thyroid, remainder
0.12	bone marrow, colon, lung, stomach
0.2	gonads

- *ICRP 103*

0.01	bone surface, skin, brain, salivary glands
0.04	bladder, liver, oesophagus, thyroid
0.08	gonads
0.12	bone marrow, colon, lung, stomach, breast, remainder

Clarification

- **Effective dose is not a scientific quantity that is "correct" for a particular age group**
- In public dose assessments, usually use three age groups - 1y, 10y and adults - in representative person calculations (Publication 101, ICRP 2006)
- For a few radionuclides, consideration of doses to the fetus may be important (isotopes of P, Ca and Sr)
- Use of constraints and reference levels that apply to all workers and all members of the public, together with optimisation, provides a pragmatic and workable system of protection

Use of *E* in Medicine

- **Measured quantities** : KAP, ESAK, $CTDI_{VOL}$, DLP
- Surveys, DRLs in measured quantities
- *E* useful in comparisons where dose distributions are different
- Effective Risk ? *Brenner, 2012; Ann ICRP 41 (3/4)*

Dose/Risk from Medical Procedures

- Accurate determination of measured quantities
- *E* a useful risk-adjusted quantity
- Associated risks at low doses are UNCERTAIN
- Effective risk gives a false impression of reliability of risk estimation

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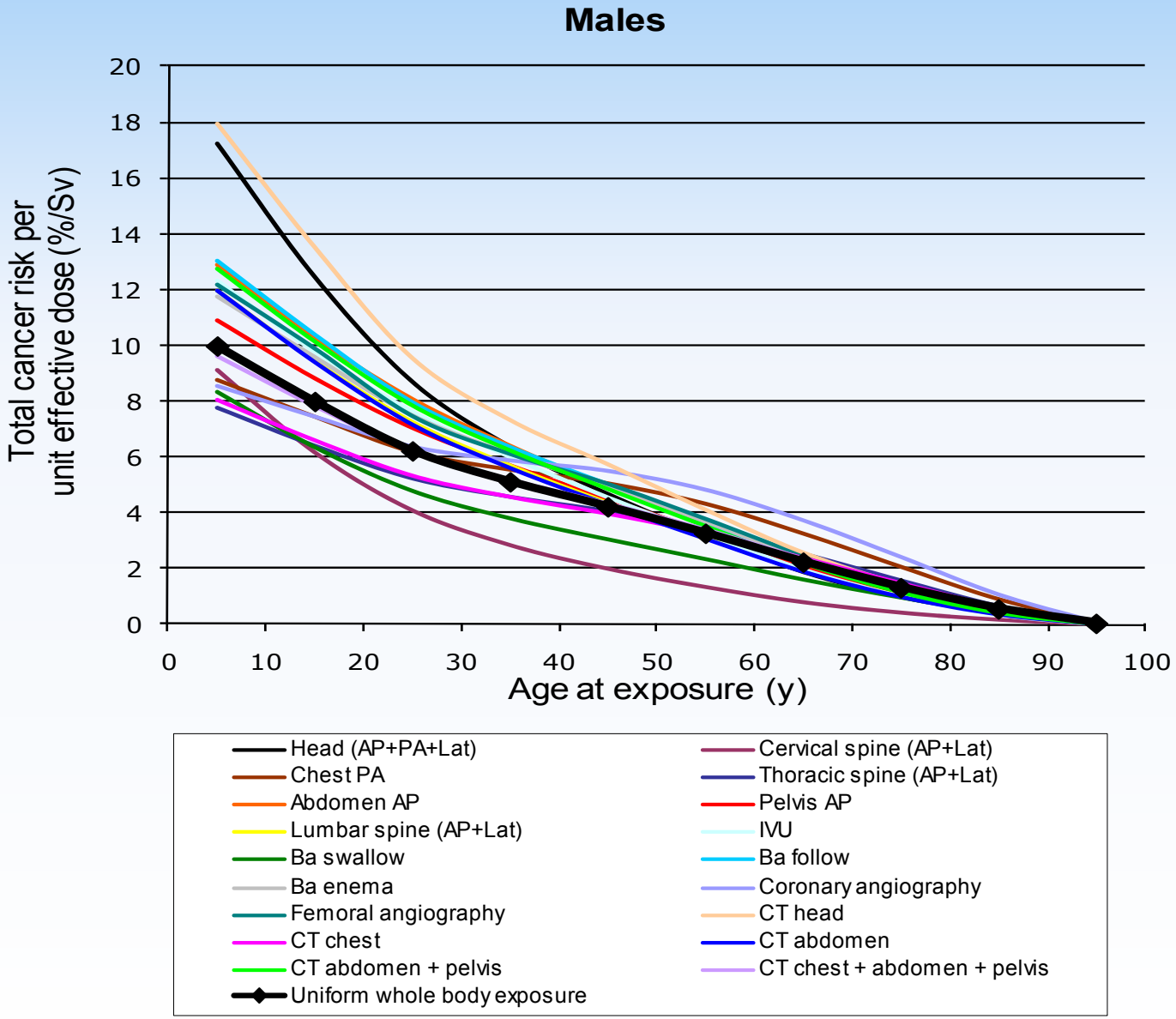
BUT can *E* be used to provide a rough indication of risk ?

Risks from medical x-ray examinations

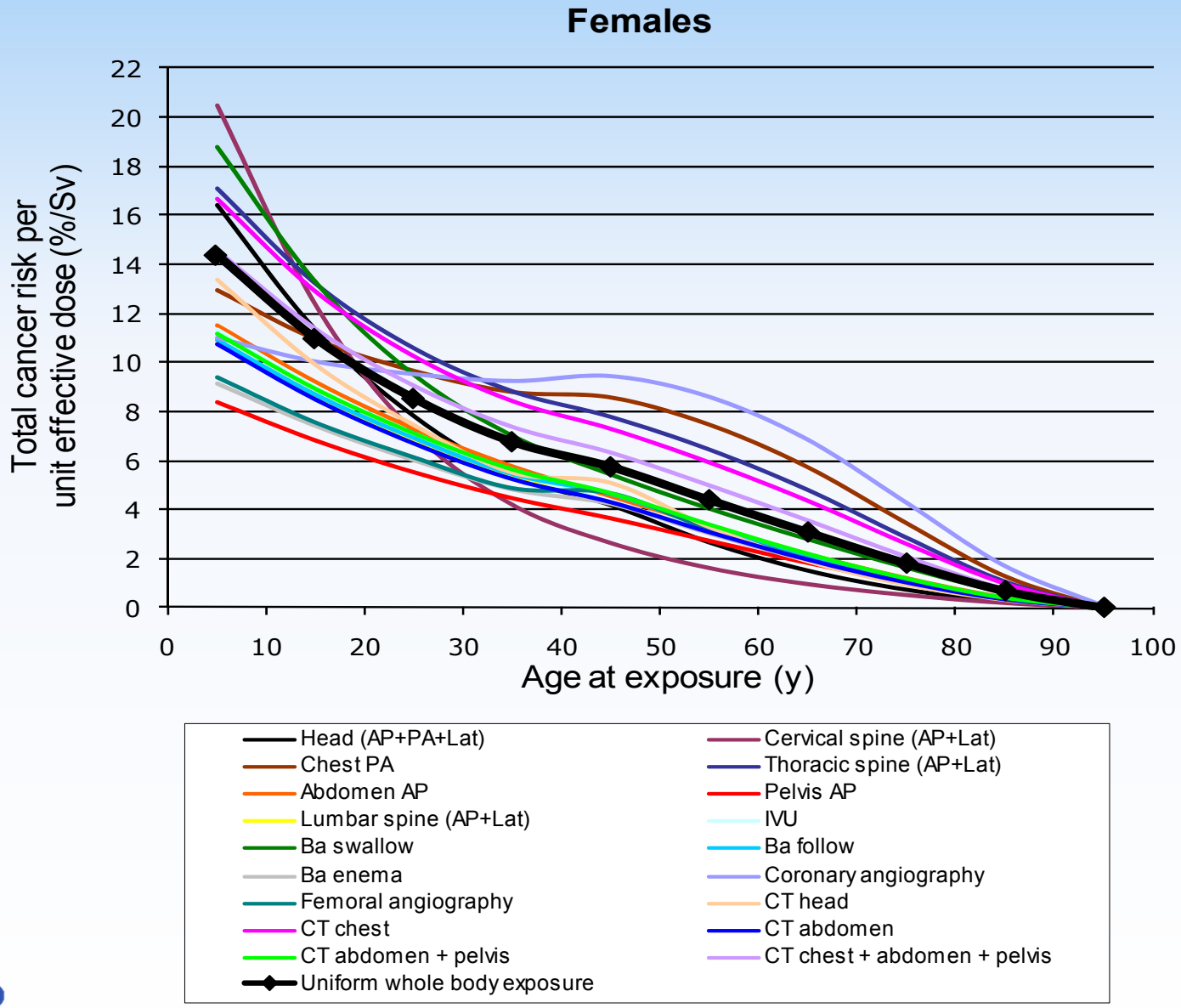
- **Organ and effective doses calculated for a range of x-ray examinations**
- **Risks from individual procedures calculated using organ doses and age- and sex-specific risk factors**
- **Risk per unit effective dose calculated for each procedure as a function of age and sex**

Wall *et al* (2011) HPA-CRCE-028

% / Sv risk from X-Ray Examinations



% / Sv risk from X-Ray Examinations



Cancer Risk Coefficients (% / Sv) for X-Ray Examinations

Region	Age group (years)									
	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99
Male										
Head	18	13	9.1	6.8	5.2	3.6	2.2	1.2	0.5	0.1
Neck	9.1	6.2	4.1	2.8	2.0	1.3	0.8	0.4	0.2	0.0
Chest	8.3	7.0	5.8	5.1	4.6	4.0	3.0	1.9	0.8	0.0
Abdo & Pelv	12	9.7	7.5	6.0	4.7	3.4	2.2	1.1	0.4	0.0
Whole body	**10**	**8.0**	**6.2**	**5.1**	**4.2**	**3.3**	**2.2**	**1.3**	**0.6**	**0.04**
Female										
Head	15	11	7.6	5.5	4.6	3.0	1.7	0.9	0.3	0.0
Neck	20	12	7.2	4.2	2.6	1.6	1.0	0.5	0.2	0.0
Chest	14	12	10	8.8	8.3	7.1	5.4	3.3	1.3	0.0
Abdo & Pelv	10	8.3	6.6	5.2	4.4	3.2	2.0	1.1	0.4	0.0
Whole body	**14**	**11**	**8.5**	**6.8**	**5.8**	**4.4**	**3.1**	**1.8**	**0.7**	**0.02**

Proposal

Use *E* as a rough indicator of possible risk from medical examinations

- MAY apply simple adjustments for age and sex, according to procedure – factors of a few higher in young children and lower at older ages
- BUT UNCERTAINTIES should be recognised
- AND not a substitute for risk analysis using organ doses in Gy – with consideration of uncertainties

Other issues

- Committed effective dose
- Collective effective dose
- Revision of dose coefficients - and previous dose assessments
- Use of specific information on physical and chemical forms of ingested and inhaled radionuclides
- Further consideration of medical applications

Next steps

- Discussion within ICRP Committees
- **Revision of report by Task Group**
- Reconsideration by Committees and Main Commission
- Public Consultation

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