EYE LENS DOSIMETRY

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Introduction

➢In April 2011 the International Commission on Radiological Protection (ICRP) reviewed recent epidemiological evidence suggesting that there are some tissue reaction effects, such as cataract induction, where threshold doses are or might be lower than previously considered.

A **limit of 0.5 Gy** has been specified, much lower than the previously set threshold doses of *5 Gy for acute exposures (> to 8 Gy for fractional exposures)*.

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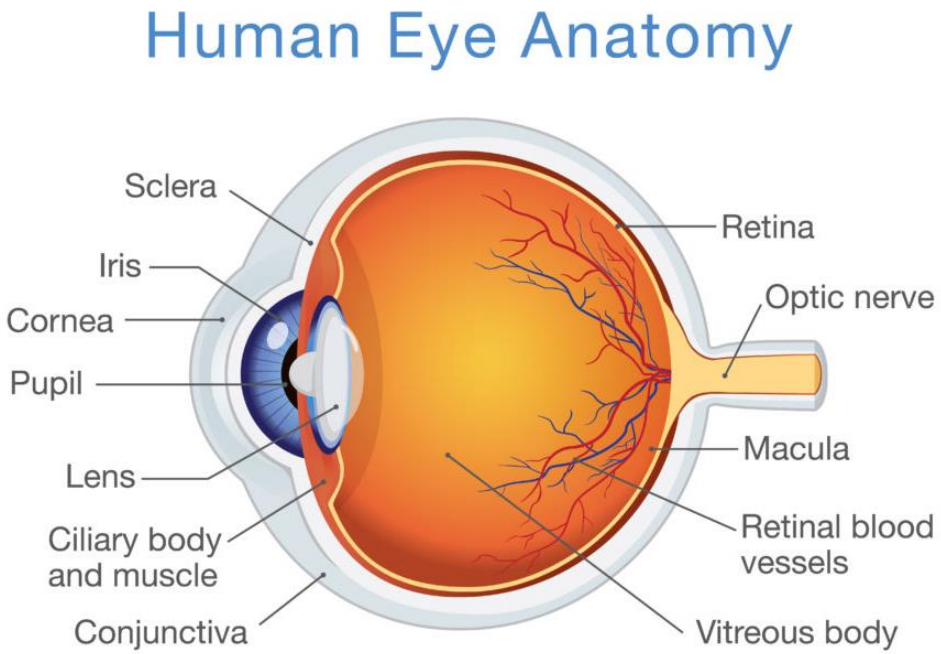
Eye lens anatomy

The eye lens is a transparent biconvex lens surrounded by a capsule.

When changing its shape, the lens focuses the light rays that pass through it (and onto the retina) in order to create clear images of objects that are positioned at various distances.



https://www.nvisioncenters.com/education/aqueous-and-vitreous/#anatomy

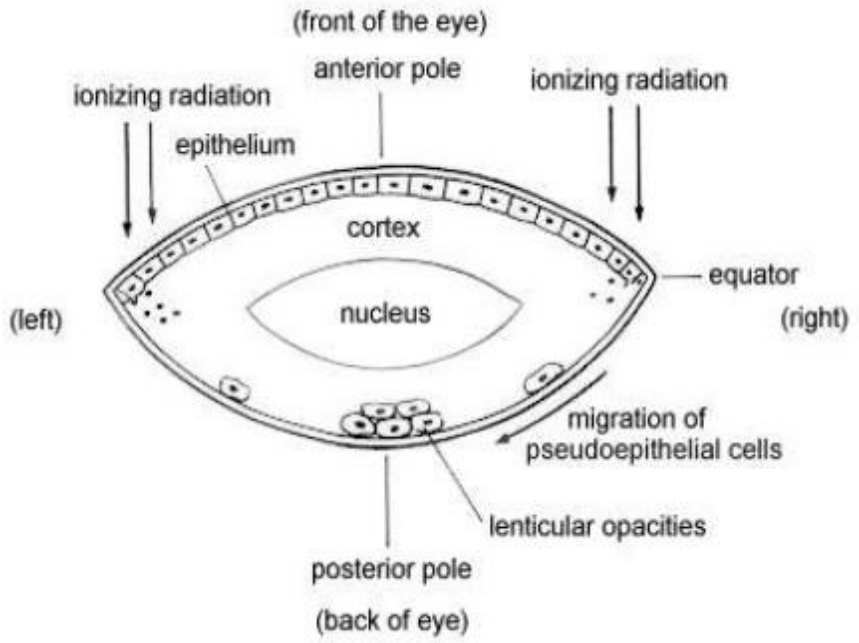
Opacification of the lens is the leading cause of blindness throughout the world

Eye lens anatomy

Lens may be regarded as a self-renewal tissue -> Cell division in the Lens epithelium continues throughout life

there is no mechanism for removal of dead cells

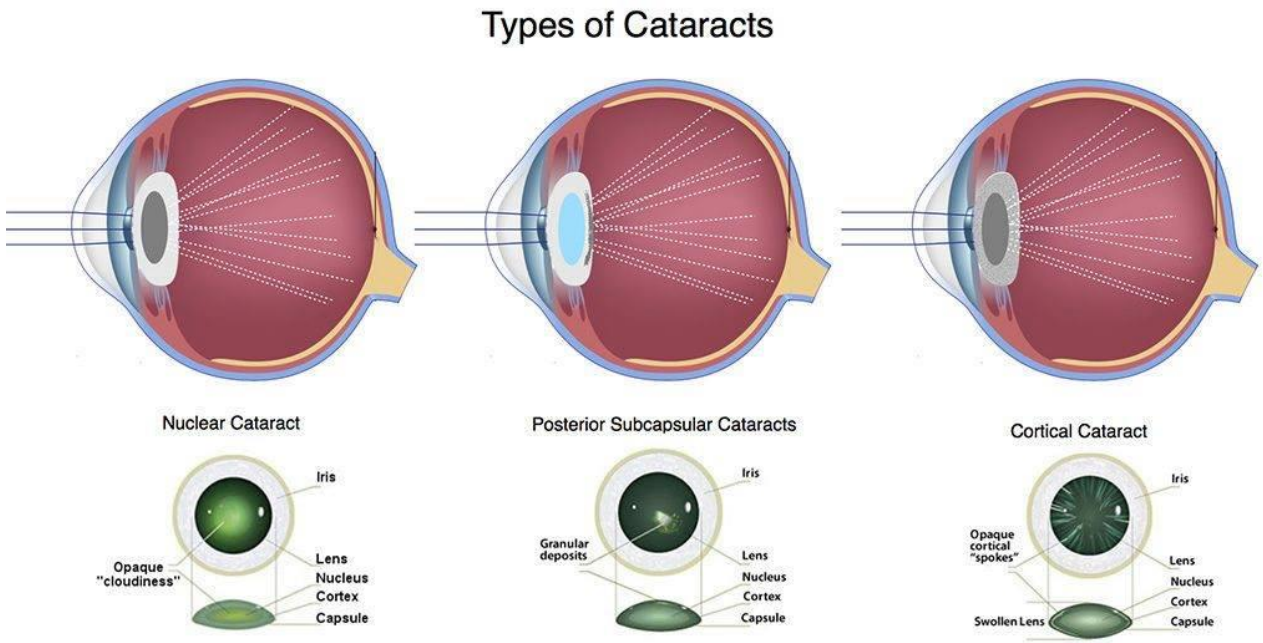
If dividing cells are injured by radiation -> they are not removed from the lens but migrate toward the posterior pole



As they are not translucent, they constitute the beginning of a cataract

Cataract

3 predominant forms of cataract depending on their anatomical location in the lens: cortical, nuclear and Posterior subcapsular (developing from aberrantly differentiating epithelial cells and resulting in opacity at the posterior pole)



https://charlottejohn.home.blog/2018/10/18/radiation-induced%e2%80%8b-cataracts-an-article-to-show-the-link-between-interventional-radiology-and-the-eye-health-of-radiologists/

Introduction

=> ICRP proposed a reduction of the annual eye lens dose equivalent limit from *150 mSv* to **20 mSv**, (or to 100mSv over a period of 5 consecutive years, provided that the dose received in any one year does not exceed 50mSv).

IAEA Safety Standards

for protecting people and the environment

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

Jointly sponsored by
EC, FAO, IAEA, ILO, OECD/NEA, PAHO, UNEP, WHO

General Safety Requirements Part 3

No. GSR Part 3

IAEA
International Atomic Energy Agency

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Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

RO 2017
www.droitfederal.admin.ch
La version électronique signée fait foi

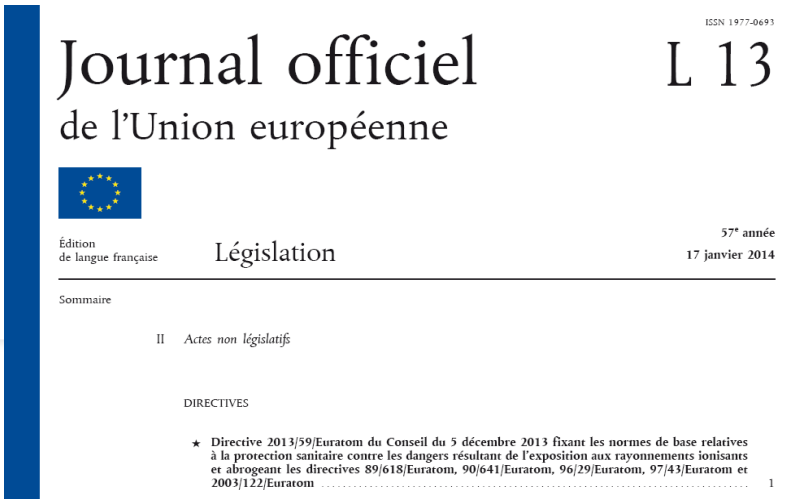
Ordonnance du DFI sur la dosimétrie individuelle et la dosimétrie de l'environnement
(Ordonnance sur la dosimétrie)

du 26 avril 2017

Le Département fédéral de l'intérieur (DFI), en accord avec l'Inspection fédérale de la sécurité nucléaire,

vu les art. 53, al. 4, 61, al. 4 et 5, 77, 167, al. 4, et 191, al. 5, de l'ordonnance du 26 avril 2017 sur la radioprotection (ORaP)[1],

arrête:

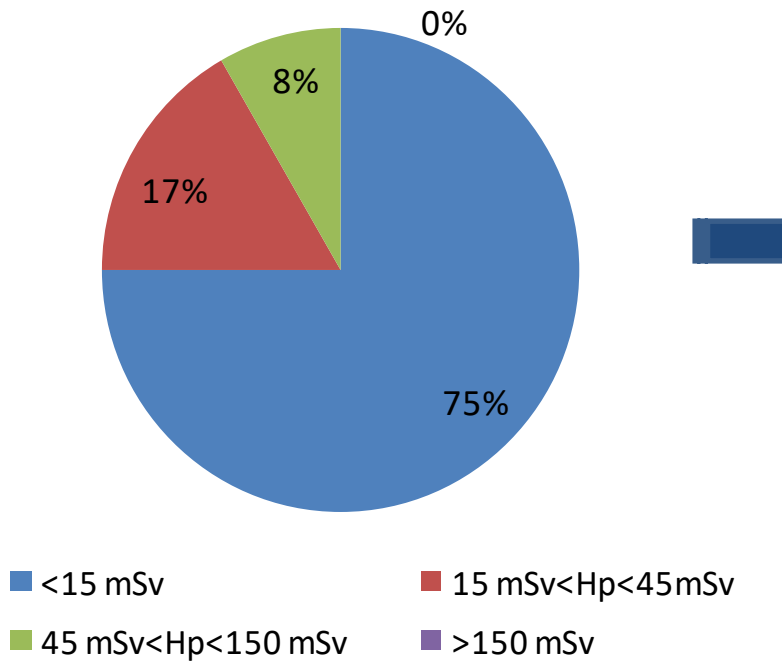


Exposure level of medical staff

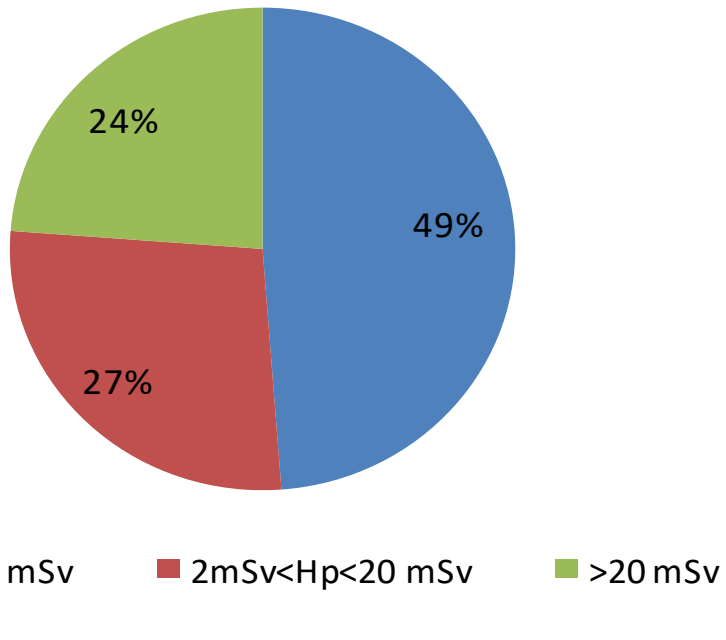
1329 eye lens dose measurements in 40 hospitals in 6 European countries

2008-2011

limit 150 mSv



limit 20 mSv



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Exposure level of medical staff

EURADOS

2013

23 EU countries

195 answers

In IR -> for 35% of the answers doses were larger than 20mSv

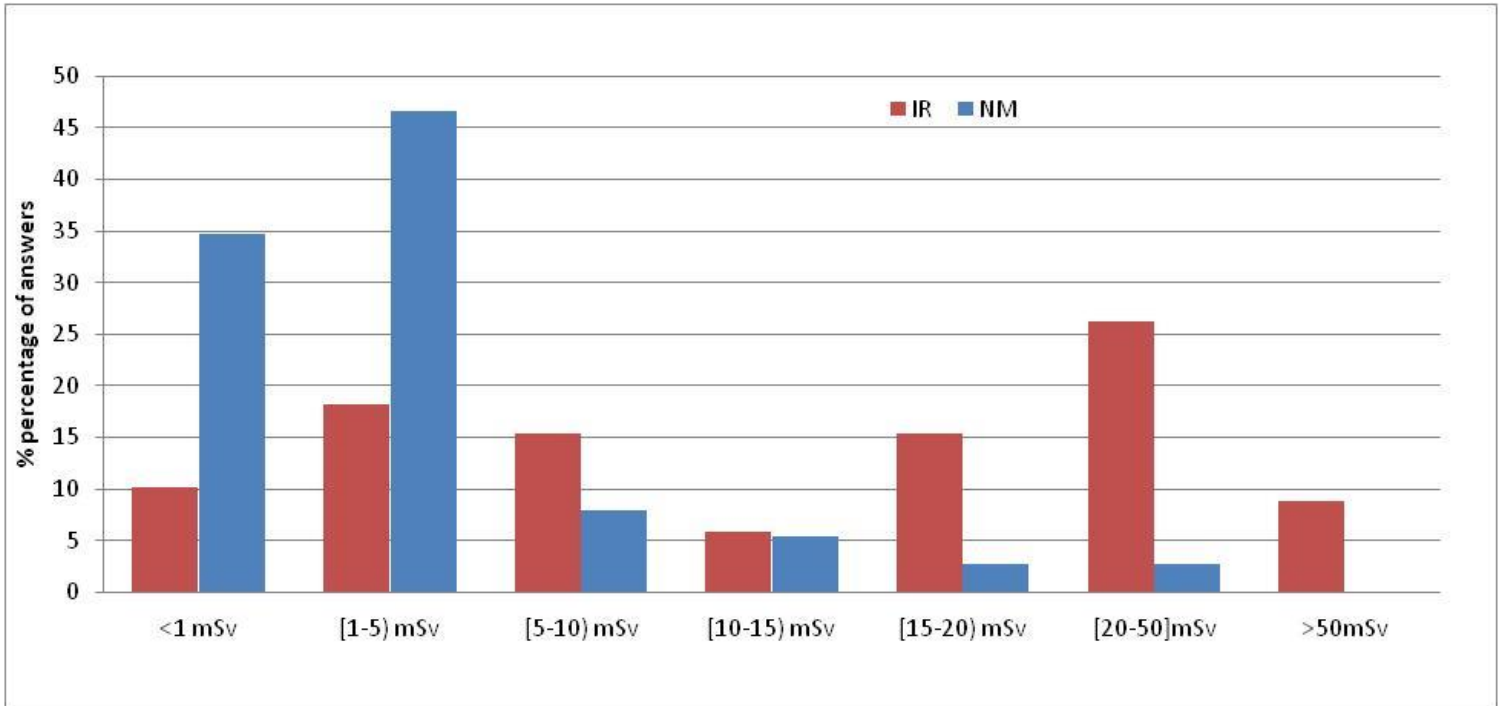
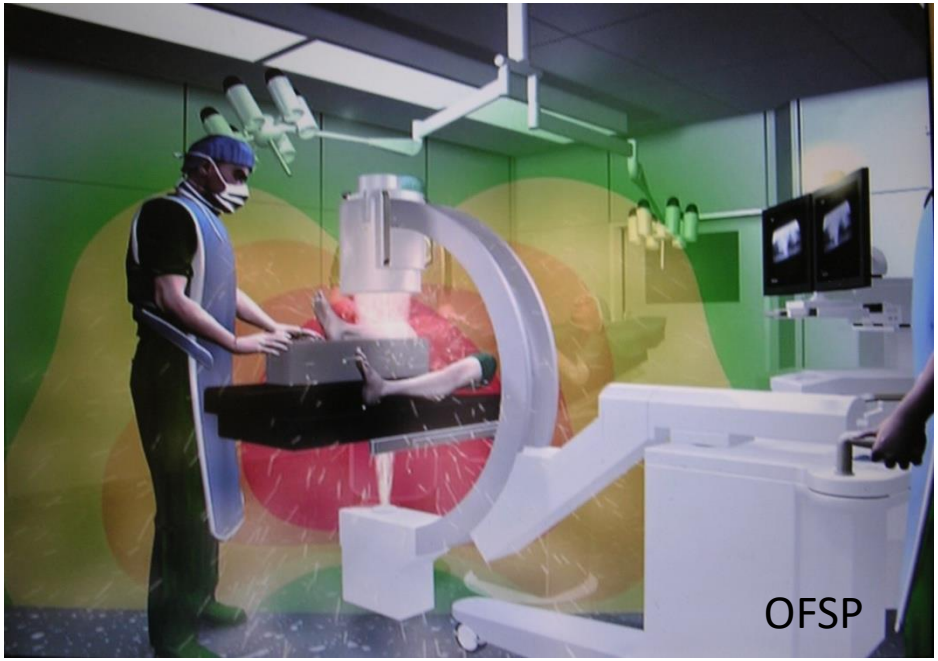


Figure 3: Percentage of responses about the distribution of the maximum eye lens dose (measured or estimated) in annual basis (Number of answers: 137 and 75 for IR and NM respectively)

E. Carinou et al.: Status of eye lens radiation dose monitoring in European hospitals.
J. Radiol. Prot. 34 (2014) 729–739

Exposure level

Medical workers perform complex fluoroscopically guided procedures in interventional radiology and cardiology -> They may receive some of the highest occupational exposures (scattered radiation)



If appropriate protection is not worn, interventionalists could receive doses to the eye that exceed the new dose limit

Ophthalmology studies have shown a 4-5x incidence of lens opacities in interventionalists vs controls (RELID study - IAEA)

When eye lens dosimetry is required

Recommendation by	Survey	Routine monitoring
IAEA TECDOC 1731 [18]	-	> 5 mSv
ISO-15382 [19]	Not specified	> 15 mSv (single year) or > 6 mSv (consecutive years)
IRPA guidance [20]	1-6 mSv	> 6 mSv

Netherlands Commission on Radiation Dosimetry Subcommittee 'Protection and Dosimetry of the Eye Lens' May 2018 DOI: 10.25030/ncs-031

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Ordonnance sur la radioprotection (ORaP)

- For staff performing interventional acts when they are placed close to the patient (particulary for: interventional radiology, cardiology, urology and angiology)
- For other staff performing interventional procedures, an evaluation must be conducted to determine if routine monitoring is required

Recommandations SSRPM

SGSMP
SSRPM
SSRFM

EYE LENS DOSIMETRY TASK GROUP RECOMMENDATIONS

- MSc. Nicolas Cherbuin, Institute of radiation physics, university hospital of Lausanne
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- Dr. Miha Furlan, Dosilab
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- PD Dr. Dr. Michael Ith, university hospital of Bern
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- MSc. Barbara Ott, federal office of public health
- Dr. Julien Ott, university hospital of Bern
- Dr. Andreas Pitzschke, Institute of radiation physics, university hospital of Lausanne
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- Dr. Elina Samara, Valais hospital
- Dr. Marta Sans Merce, university hospital of Geneva
- Dr. Alexander Schegerer, Hirslanden
- MSc. Anja Stuessi, university hospital of Zurich

Centre hospitalier universitaire vaudois

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dosilab

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Made available on the 7th of December 2021

SGSMP
SSRPM
SSRFM

Schweizerische Gesellschaft für Strahlenbiologie und Medizinische Physik
Société Suisse de Radiobiologie et de Physique Médicale
Società Svizzera di Radiobiologia e di Fisica Medica
Swiss Society of Radiobiology and Medical Physics

SSRMP Communication

Biweekly News

Latest NEWS

06.12.2021 - **Eye Lens Dosimetry**

- SSRMP Recommendations No. 17 have been published

06.12.2021 - **QA of systems for SABR**

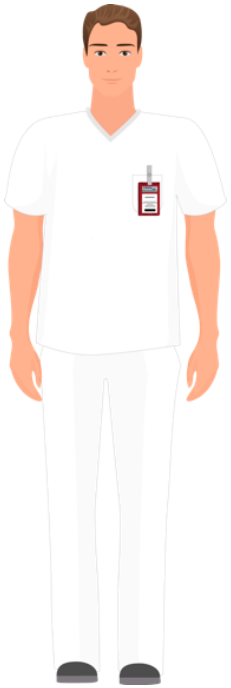
- SSRMP Recommendations No. 18 have been published

02.12.2021 - **Education for the non-physics healthcare professions**

- EFOMP call for application for joining the working group

Motivation

Eye lens dosimetry can be a difficult task !



Objective

Drafting recommendations for lens dosimetry in the medical sector :

Who

When

How

These recommendations apply only to personnel working with fluoroscopy systems

Swiss legislation

4 ways to determine eye lens doses (ODosim, Art. 11)

1. Whole body dosemeter worn at the thorax level **without** protective glasses

$H_{eyelens} = H_{under}(0,07) + f_L * H_{over}(0,07)$

f_L = GCF / 1

2. Whole body dosemeter worn at the thorax level **with** protective glasses

$H_{eyelens} = H_{under}(0,07) + f_L * H_{over}(0,07)$

f_L = GCF / DRF

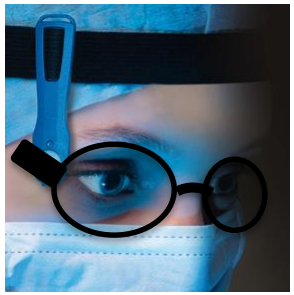
Swiss legislation

4 ways to determine eye lens doses (ODosim, Art. 11)

3. Eye lens dosemeter worn **under** the protective glasses

$H_p(3)$ or $H_p(0.07)$

Directly measured by the eye lens dosemeter approved by the FOPH



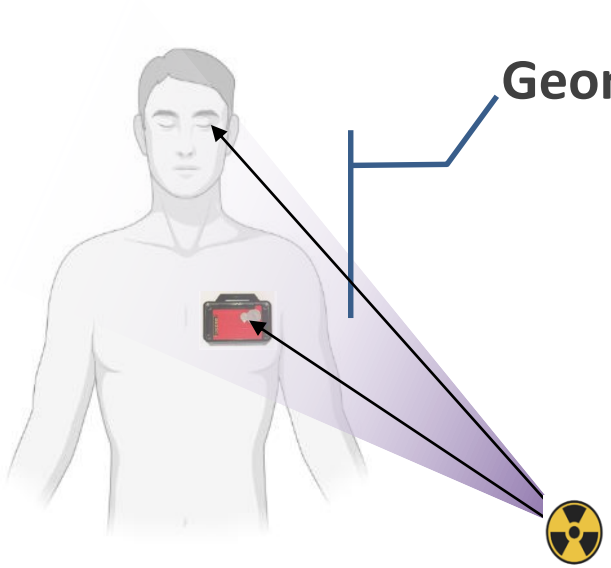
3. Eye lens dosemeter worn **over** the protective glasses

$H_{eyelens} = H_p(0,07) * f_L$ or

$H_{eyelens} = H_p(3) * f_L$

$f_L = 1/$ DRF

Geometrical correction factor- GCF



Geometrical correction factor? (*GCF*)

Literature:

58 publications (2009-2019)

➢ 0.28 < GCF < 1.1

Analysis of Dosilab data:

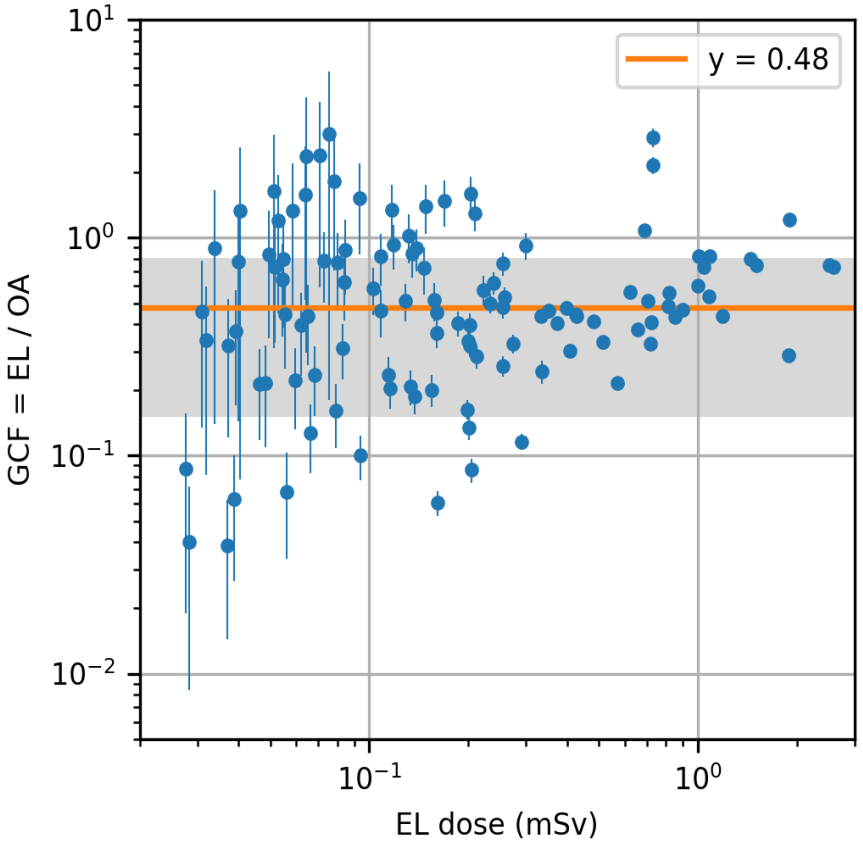
- 667 datasets (dosemeters OA + EL)
- 33 workers de 11 centres
- Data from 2017 à 2020
  - ➢ mean GCF : 0.48 ± 0.33

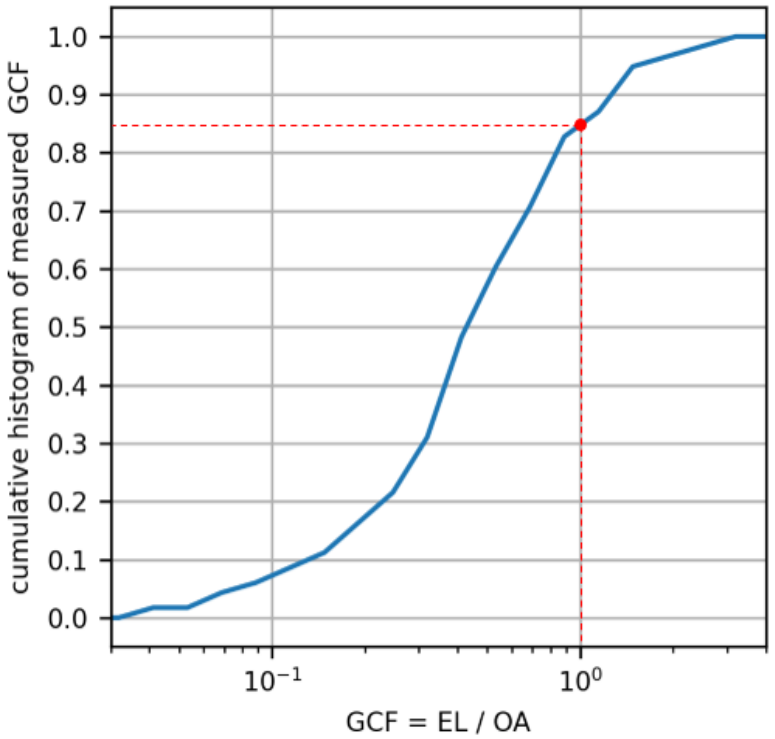
Very large dependence on working habits and conditions

➢ **Recommended GCF : 1**

GCF

Dosilab data :





84% of the ratios EL/OA have a value lower than 1 -> GCF = 1 represents a conservative value for 84% of the considered cases.

Dose reduction factor- DRF

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Dose reduction factor- DRF

Dose reduction factor? (*DRF*)

Large variability of the effectiveness of the eye lens protection means…
Values also variable in the literature …

- **Recommended DRF value : 2 (conservative)**
- **Individual evaluation if annual eye lens dose > 15mSv**
- **Inform the user about his/her correction factor**

Dose reduction factor- DRF

Protection	Pb equivalent thickness (mm)	DRF literature	recommended DRF value	Recommended way to use and comments
Radiation safety glasses	0.3-0.75 *	1.1-33	2**	- should be adapted to the geometry of the face - contact between the nose and cheeks and side shielding are of great importance
Radiation safety masks	0.1	2-4	Measurements should be performed	- cover a larger area than glasses, thus reducing the exposure to other regions of the head that would make a significant contribution to the dose to the eye lenses from backscatter - Attention should be paid to the mask shape and size
Ceiling suspended shield	0.5	1.5-33	--	- should be positioned as close to the patient - The effect strongly depends on its position
Protective drapes	0.25	1.5-25	--	- To be used in procedures where the use of a ceiling-suspended lead shield is not possible - Warning: should never be in the primary beam
Lead cabinet	2.0	28, 68	--	Protect the operator to a higher degree

** According to the Swiss ordinance for X-rays, annex 2, the minimum lead equivalent thickness for the lead glasses should be 0.5mm*

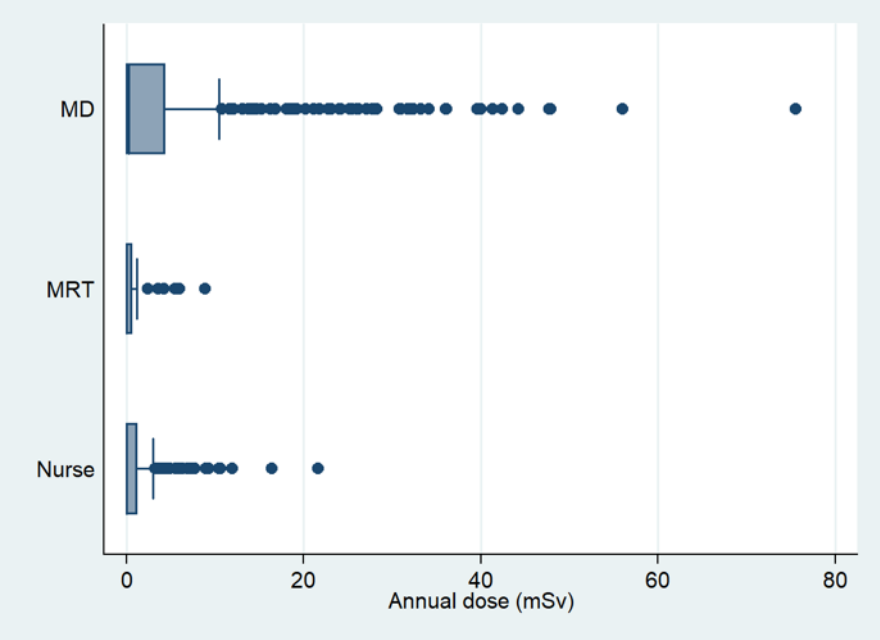
*** Radiation safety glasses – wearing lead glasses can be an effective way of protecting the eye lens if ceiling-suspended shields cannot be used. They are most effective when the exposure is frontal or, put differently, when the operator is looking through the glasses to the scattering object.*

When to measure the eye lens dose

Annual estimated EL dose for a group of professionals	Routine eye lens dosimetry	Dosemeter for eye lens dose estimation	Position of dosemeter
Below **6 mSv**	Not mandatory	--	--
Between **6 mSv** and **15 mSv**	mandatory	OA dosemeter or EL dosemeter	- OA dosemeter: at the chest (above the lead apron) - EL dosemeter: near the most exposed eye below the radiation protection means
Above **15 mSv**	mandatory	EL dosemeter	- EL dosemeter: near the most exposed eye below the radiation protection means

Who is concerned

Healthcare professionals concerned for routine eye lens monitoring



Annual eye lens dose estimations in mSv for different healthcare professionals .

Boxes represent 1st, median and 3rd quartiles values. The whisker represents maximum non extreme values (Q3+1.5(Q1-Q3)), and the dots are outliers.*

- MD: Physicians
  the group includes both first and second operators since their position in relation to the patient may change during the procedure
- MRT: Medical radiation technologists
- Nurses
  the group includes all nurses and assisting personnel

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Who is concerned

Nurses and MRT

Interventional procedure	N	Min	25th	50th	75th	90th	95th	Max
Anesthesiology *	57	0.0	0.0	0.0	0.6	1.2	2.4	6.9
Angiology	10	0.0	0.0	0.0	0.5	0.7	0.8	0.8
Electrophysiology	26	0.0	0.0	0.1	0.6	2.4	4.9	10.6
Gastroenterology	44	0.0	0.0	0.2	1.2	3.6	4.8	7.2
Interventional cardiology	163	0.0	0.0	0.7	2.5	4.2	7.4	21.6
Interventional radiology	110	0.0	0.0	0.0	0.0	1.8	3.6	25.2
Operating theatre**	23	0.0	0.0	0.0	0.0	0.2	0.6	1.9
Urology	20	0.0	0.0	0.0	0.0	0.8	1.6	2.1
Vascular surgery	14	0.0	0.2	0.8	1.2	3.3	3.5	3.5

** The term "Anesthesiology" refers to the staff that sedates the patient*

*** The term "Operating theatre" was used for different procedures performed in the operating theatre (neurosurgery, orthopedics, pain management procedures, visceral surgery)*

Who is concerned

Physicians

Interventional procedure	N	Min	25th	50th	75th	90th	95th	Max
Anesthesiology*	54	0.0	0.0	0.0	0.3	2.4	2.4	4.8
Angiology	16	0.0	3.3	5.7	13.7	21.1	27.8	27.8
Electrophysiology	25	0.0	0.0	0.1	0.6	2.3	4.4	4.8
Gastroenterology	20	0.0	0.0	1.4	3.6	7.1	8.4	9.6
Interventional cardiology	151	0.0	0.0	1.4	10.4	31.0	39.6	47.9
Interventional radiology	99	0.0	0.0	0.0	2.4	6.6	8.3	75.5
Neurosurgery **	9	0.0	0.0	0.0	0.2	25.2	25.2	25.2
Orthopedics	12	0.0	0.0	0.2	2.7	7.4	8.1	8.1
Pain management**	2	0.0	0.0	8.1	16.2	16.2	16.2	16.2
Pneumology**	2	0.0	0.0	1.0	2.1	2.1	2.1	2.1
Urology	37	0.0	0.0	0.0	1.2	1.7	8.4	8.4
Vascular surgery	35	0.0	0.6	4.8	16.8	26.2	34.1	36
Visceral surgery **	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0

*** Low number of participants*

Eye lens dosimetry mandatory

Eye lens dosimetry mandatory with specific EL dosemeter

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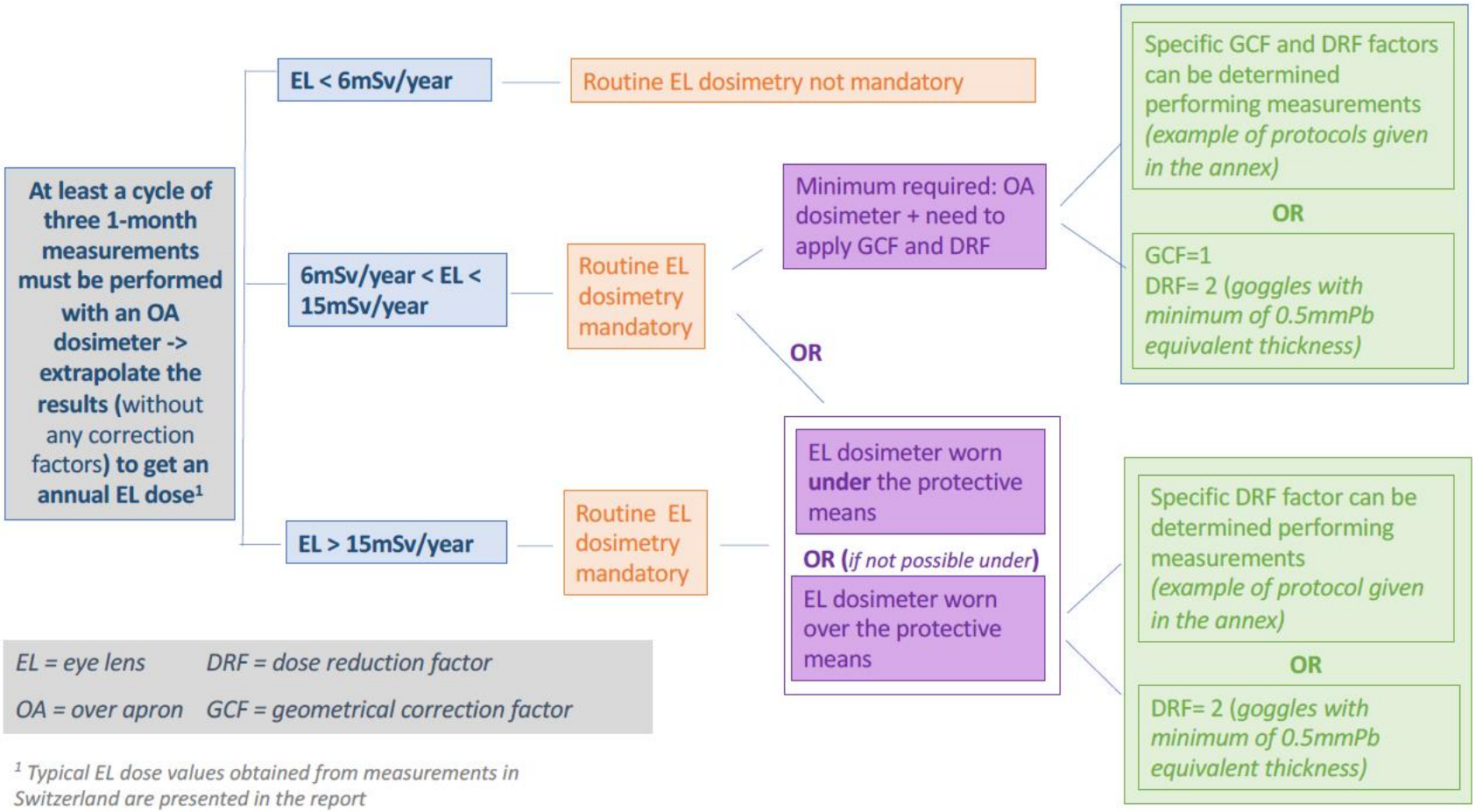
How it can by applied?

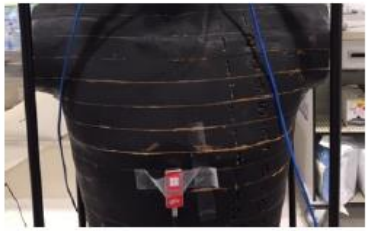


According to the IRPA Guidance 2017, the annual EL dose cut-off of 6 mSv should be used to determine the professionals that need to be regularly monitored for EL exposure.

How it can be applied?

2 interesting annexes :
Determination of individual GCF and DRF with dedicated dosimeters

Typical setup at fluoroscopy unit (i.e. in cardiology):
- detector position: LAO 30°
- distance patient – operator's eyes: 1 m
- Phantom representing the medical staff
- Dosimeters on the eye's surface



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