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WEBINAR of the Federal Commission on Radiation Protection (KSR):
Radiation Protection in Medicine
Friday, 29th January 2021

New developments in occupational exposure monitoring

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Division of Radiological Protection
Non-ionising Radiation and Dosimetry Section

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Dosimetry in Switzerland: Facts and Figures

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Personal Dosimetry Services

- 10 approved personal dosimetry services for external exposure, $H_p(10)$ & $H_p(0.07)$
- 1 service approved for eye lens dosimeters, $H_p(3)$ New!

CERN	Organisation européenne pour la recherche nucléaire, Geneva
Dosilab	Dosilab AG, Köniz
IRA	Institut de radiophysique, Lausanne
KKB	Kernkraftwerk Beznau, Döttingen
KKG	Kernkraftwerk Gösgen, Däniken
KKL	Kernkraftwerk Leibstadt, Leibstadt
KKM	Kernkraftwerk Mühleberg, Mühleberg
PEDOS	PEDOS AG, Muri b. Bern
PSI	Paul Scherrer Institut, Villigen
Suva	Schweizerische Unfallversicherungsanstalt, Luzern

→ Must participate in annual intercomparison exercises (blind test for the first time in 2017)

- 8 approved personal dosimetry services for incorporation

Service	Method	Rad.	Detector	Nuclides
HUG	Whole-body counter	γ	NaI Ge	Cr-51, Fe-59, Co-57, Co-58, Co-60, Zn-65, Ga-67, Sr-85, Tc-99m, In-111, Cs-134, Cs-137, Sm-153, Lu-177, Re-186, Re-188, Tl-201
IRA	Thyroid	γ	NaI	I-123, I-125, I-131
	Urine	β	Scint	H-3, C-14, P-32, P-33, S-35, Ca-45
		β	PC	Sr-90
	Urine, stool	α	Si	Po-210, Ra-226, U-234, U-235, U-238, Pu-239, Am-241
Labor Spiez New!	Whole-body counter	γ	Ge	Cr-51, Co-57, Co-58, Fe-59, Co-60, Zn-65, Ga-67, Sr-85, Tc-99m, In-111, Ba-133, Cs-134, Cs-137, Eu-152, Sm-153, Eu-154, Lu-177, Re-186, Re-188, Tl-201
KKM	Whole-body counter	γ	NaI	Cr-51, Fe-59, Co-58, Co-60, Sr-85, Tc-99m, Cs-134, Cs-137
	Thyroid	γ	NaI	I-131
mb-microtec	Urine	β	Scint	H-3
PSI	Whole-body counter	γ	Ge	Cr-51, Fe-59, Co-57, Co-58, Co-60, Zn-65, Ga-67, Sr-85, Tc-99m, In-111, Cs-134, Cs-137, Sm-153, Lu-177, Re-186, Re-188, Tl-201
	Thyroid	γ	NaI	I-123, I-124, I-125, I-131
	Urine	β	Scint	H-3, C-14, P-32, P-33, S-35, Ca-45, Ni-63, Sr-89, Sr-90, Y-90, Er-169
	Urine, stool	α	Si	Po-210, Ra-226, Th-228, Th-232, U-234, U-235, U-238, Np-237, Pu-238, Pu-239, Pu-240, Am-241, Cm-242, Cm-244
RC TRITEC	Urine	β	Scint	H-3, C-14
Suva	Urine	β	Scint	H-3, C-14, P-32, P-33, S-35, Ca-45

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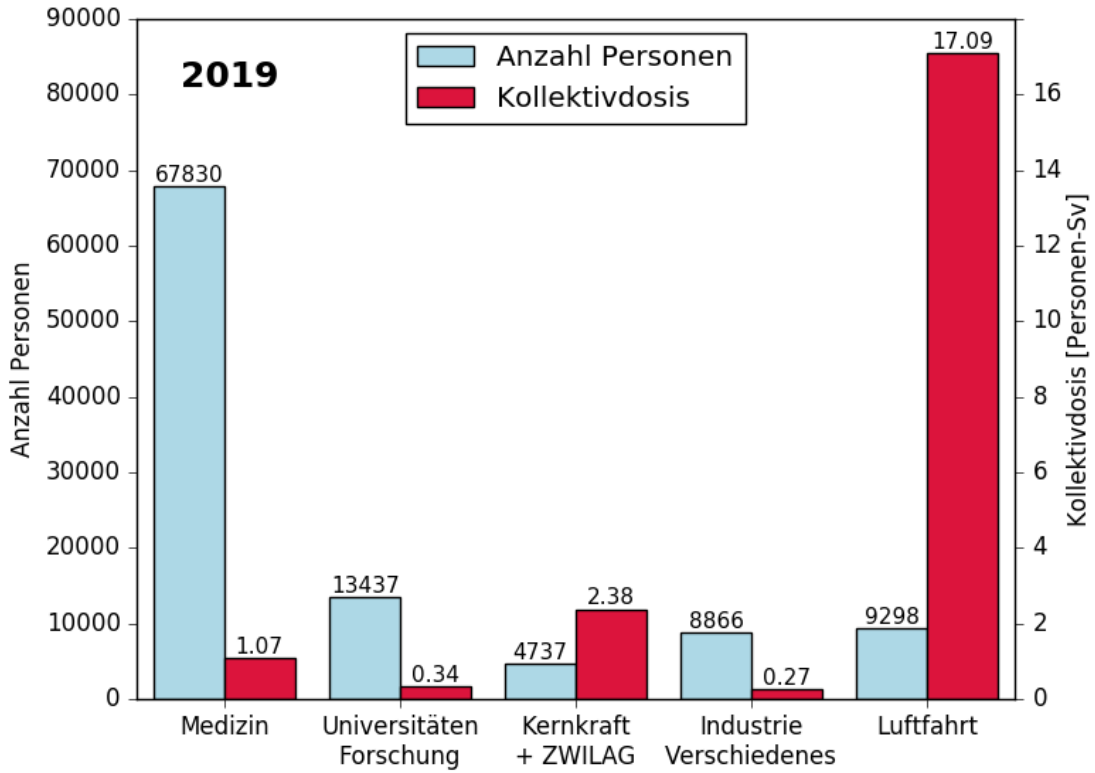
Occupational Exposure 2019

Number of persons and collective doses, external and internal irradiation



→ Annual dosimetry report published by the FOPH

https://www.bag.admin.ch/bag/de/home/das-bag/publikationen/taetigkeitsberichte/jahresberichte-strahlenschutz-umweltradioaktivitaet-und-dosimetrie.html

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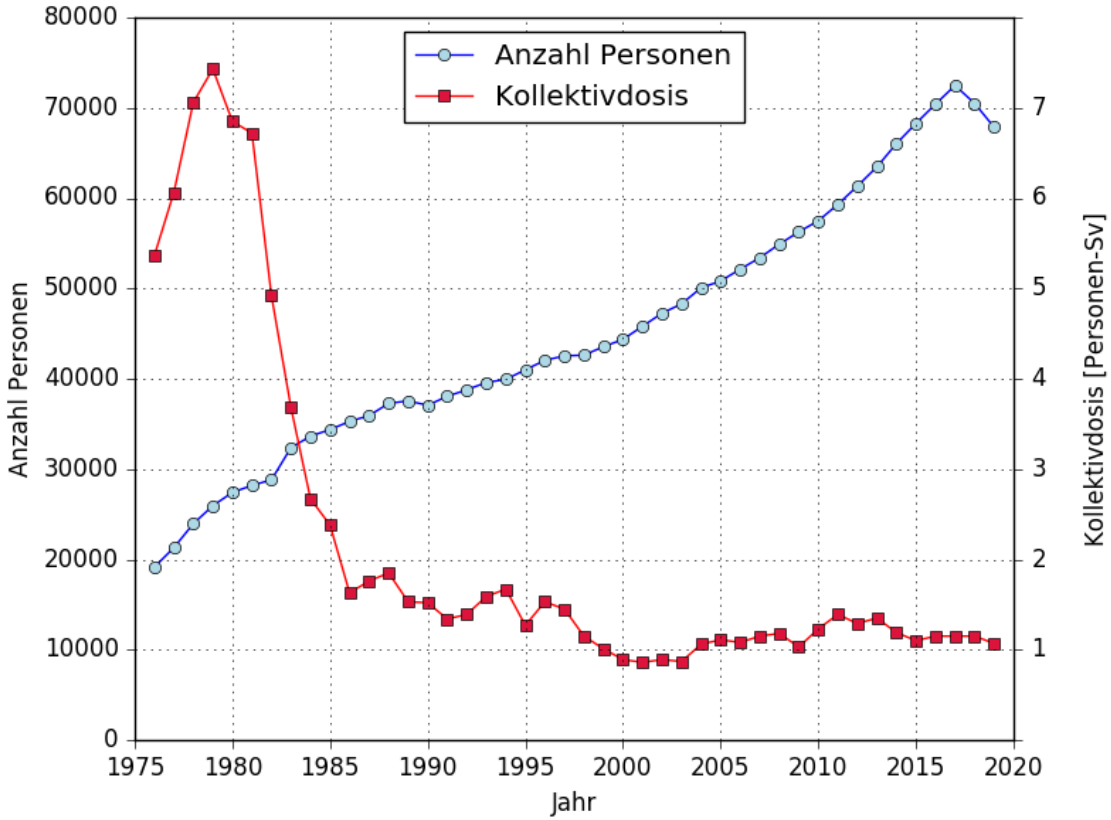
External exposure in the medical sector since 1976



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Hand doses in 2019

Dose interval [mSv]	Medicine	Universities, Research	Nuclear power plants and ZWILAG	Industry and misc.	Total
= 0	1147	220	40	44	1451
0.1 - 25.0	755	61	48	33	897
25.1 - 50.0	95	3		1	99
50.1 - 75.0	42	1			43
75.1 - 100.0	20	2			22
100.1 - 125.0	16				16
125.1 - 150.0	14				14
150.1 - 175.0	8	1			9
175.1 - 200.0	9				9
200.1 - 225.0	2				2
225.1 - 250.0	4				4
250.1 - 275.0	1				1
275.1 - 300.0	2				2
300.1 - 325.0	2				2
325.1 - 350.0	1				1
350.1 - 375.0	1				1
375.1 - 400.0	1				1
400.1 - 425.0					
425.1 - 450.0	1				1
450.1 - 475.0					
475.1 - 500.0					
> 500.0					
Total	2121	288	88	78	2575

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Dose limit exceedances since 1995

Year	Sector	Source	Dose	Notes
1995	hospital	X	E = 36.6 mSv	orthopedics, fluoroscopy
	industry	H-3	E = 24.6 mSv	incorporation
1996	industry	H-3	E = 5.2 mSv	incorporation (pregnancy)
	industry	H-3	E = 29 mSv	incorporation
1997	industry	Ir-192	E = 83 mSv	gammagraphy
	industry	H-3	E = 4.6 mSv	incorporation (pregnancy)
	hospital	X	H_{extr} = 517 mSv	interventional radiology
1998	hospital	X	E = 22.8 mSv	unclear incident
2002	hospital	Co-60	E = 22.8 mSv	radiotherapy
	hospital	I-131	H_{extr} = 1256 mSv	nuclear medicine, contamination
2004	dentist	X	E = 22.2 mSv	unclear incident
2005	hospital	X	E = 20.2 mSv	cardiology, fluoroscopy
2007	hospital	Y-90	H_{extr} = 1300 mSv	nuclear medicine
2009	NPP	g	E = 37.8 mSv E = 25.4 mSv	revision work, 2 cases
2010	NPP	g	E = 28 mSv H_{extr} = 7500 mSv	revision work, diver
	hospital	X	E = 30.2 mSv	angiography, fluoroscopy
	hospital	Y-90	H_{extr} = 1000 mSv	research
2011	hospital	X	E = 27 mSv	cardiology, fluoroscopy
	hospital	Y-90	H_{extr} = 2000 mSv	nuclear medicine, contamination
	industry	e^-, g	E = 278 mSv	electron beam cross-linking system
2012	hospital	Y-90	H_{extr} = 1000 mSv	nuclear medicine
2014	hospital / industry	X	H_{extr} = 700 mSv	repair of a fluoroscopy device
2016	hospital	Unknown	E = 24.1 mSv	nuclear medicine
2017	hospital	unknown	E = 29.6 mSv	emergency ward
2018	hospital	PET	H_{extr} = 552 mSv	nuclear medicine
	hospital	PET	H_{extr} = 562 mSv	nuclear medicine
2019	hospital	X	$H_{eyelens}$ = 21 – 73 mSv	25 cases in interventional cardiology, int. radiology, orthopedic surgery

2019: 25 cases in
- int. cardiology
- int. radiology
- orthopedic surgery

$H_{eyelens}$ = 21 – 73 mSv

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Eye Lens Dosimetry

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Report of the Eye Lens Working Group

Swiss Society of Radiobiology and Medical Physics (SSRMP)

- Members of the working group

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- Report is not published and has yet to be reviewed by the SSRMP Scientific Committee

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Report of the Eye Lens Working Group

- Recommendations are addressed to personnel working with fluoroscopy systems
- How and when to measure or estimate the eye lens dose
- Geometrical correction factor (GCF)
- Dose reduction factor (DRF) due to the RP means
- Calibration of dosimeters
- Categories of medical staff that require routine EL monitoring
- Summary

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4 ways to determine eye lens dose

(Dosimetry Ordinance, Art. 11)

1. Whole body (WB) Dosimeter worn at chest level and without EL protective means

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

2. WB dosimeter worn at chest level and EL protective means (glasses, etc.)

   $H_{eyelens} = H_{under}(0,07) + f_L * H_{over}(0,07)$
   f_L = geometrical correction factor / dose reduction factor due to the RP means

3. Eye lens dosimeter under the protective means

   directly measured with an FOPH approved EL dosimeter, $H_p(3)$ or $H_p(0.07)$

4. Eye lens dosimeter over the protective means

   $H_{eyelens} = H_p(0,07) * f_L$ or $H_{eyelens} = H_p(3) * f_L$
   f_L = 1/ dose reduction factor

Correction factors (f_L / GCF / DRF)

When wearing protective glasses, the radiological protection expert determines an individual correction factor $f_L \leq 1$ in agreement with the supervisory authority and communicates this to the personal dosimetry service.

Dosimetry Ordinance, Art. 11

The working group recommends:

→ a geometrical correction factor (GCF) = 1

→ dose reduction factor (DRF) = 2

(conservative values, based on a literature review & data from Dosilab)

Conservative factor proposed by the FOPH: f_L = GCF / DRF = 0.5

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Determination of an individual correction factor f_L (and GCF, DRF)

Method 1: Determination of correction factor with dedicated high sensivity dosimeters

Measurement positions:
1. close to the OA dosimeter (worn on the chest)
2. close to the more exposed eye, under the protective equipment (glasses)
3. close to the more exposed eye, over the protective equipment

Duration: until a cumulative dose of 0.5 mSv is reached (but no longer than 60 days)

Suitable dosimeters:
High sensitivity LiF : Mg, Cu, P thermoluminescent (TL) detectors (Harshaw TLD-100H, RadPro MCP-N), in sealed water tight plastic bags
$Li_2B_4O_7$: Cu TL detectors (Panasonic UD-807), encapsulated in a water tight and disinfectable holder

→ detector materials with strong energy dependence (e.g. Al_2O_3:C) are not advised for this purpose

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Determination of an individual correction factor f_L (and GCF, DRF)

Method 2: determination of f_L using EL and OA dosimeters

The person consistently wears a EL and an OA dosimeter

Measurement positions:
El dosimeter under the protective equipment, as close as possible to the more exposed eye

Duration: at least 2-3 months

Limitations:
long measuring time and possible loss of data usability if the two dosimeters are not reliably worn simultaneously

(Method 3: determination of DRF using a phantom)

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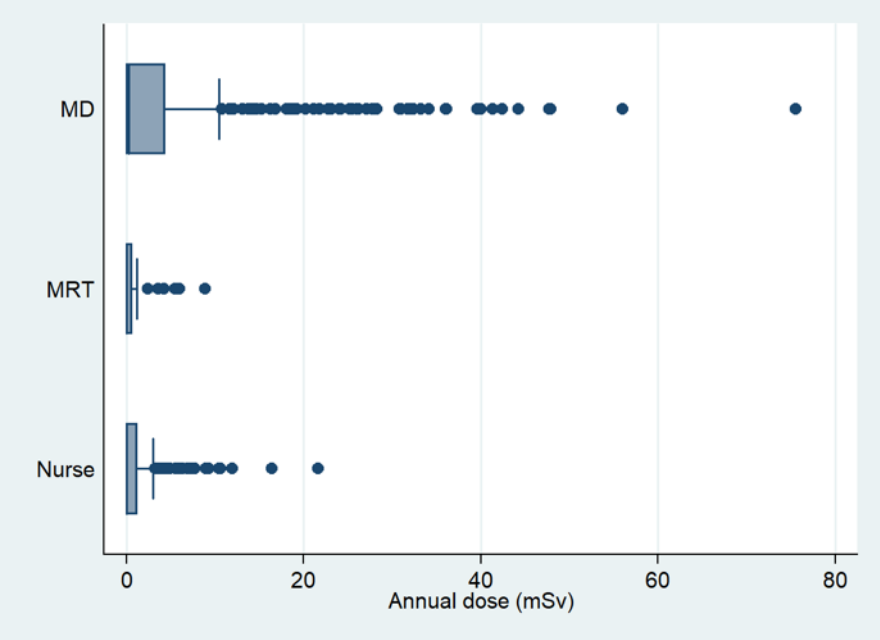
Identifying the categories of medical staff that need to be monitored for EL exposure



Annual eye lens dose estimations in mSv according to the profession.

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

Measurements with an **over-apron dosimeter**, performed in the following centers:
Hôpitaux universitaires de Genève (HUG), Centre hospitalier universitaire Vaudois (CHUV), Universitätsspital Basel (USB), Inselspital, Sion hospital and Hirslanden clinics

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Annual EL dose estimations in mSv for physicians performing interventional procedures

Interventional procedure category	N	Min	25	50	75	90	95	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
Pulmonology**	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

90^{th} percentile value ≥ 6 mSv
→ EL monitoring necessary

90^{th} percentile value ≥ 15 mSv
→ EL dosimeter recommended

Angiology procedures
Interventional cardiology
Vascular surgery

*** Low numbers of participants*

* *The term "Anesthesiology" refers to the staff that sedates the patient and not to interventional procedures*

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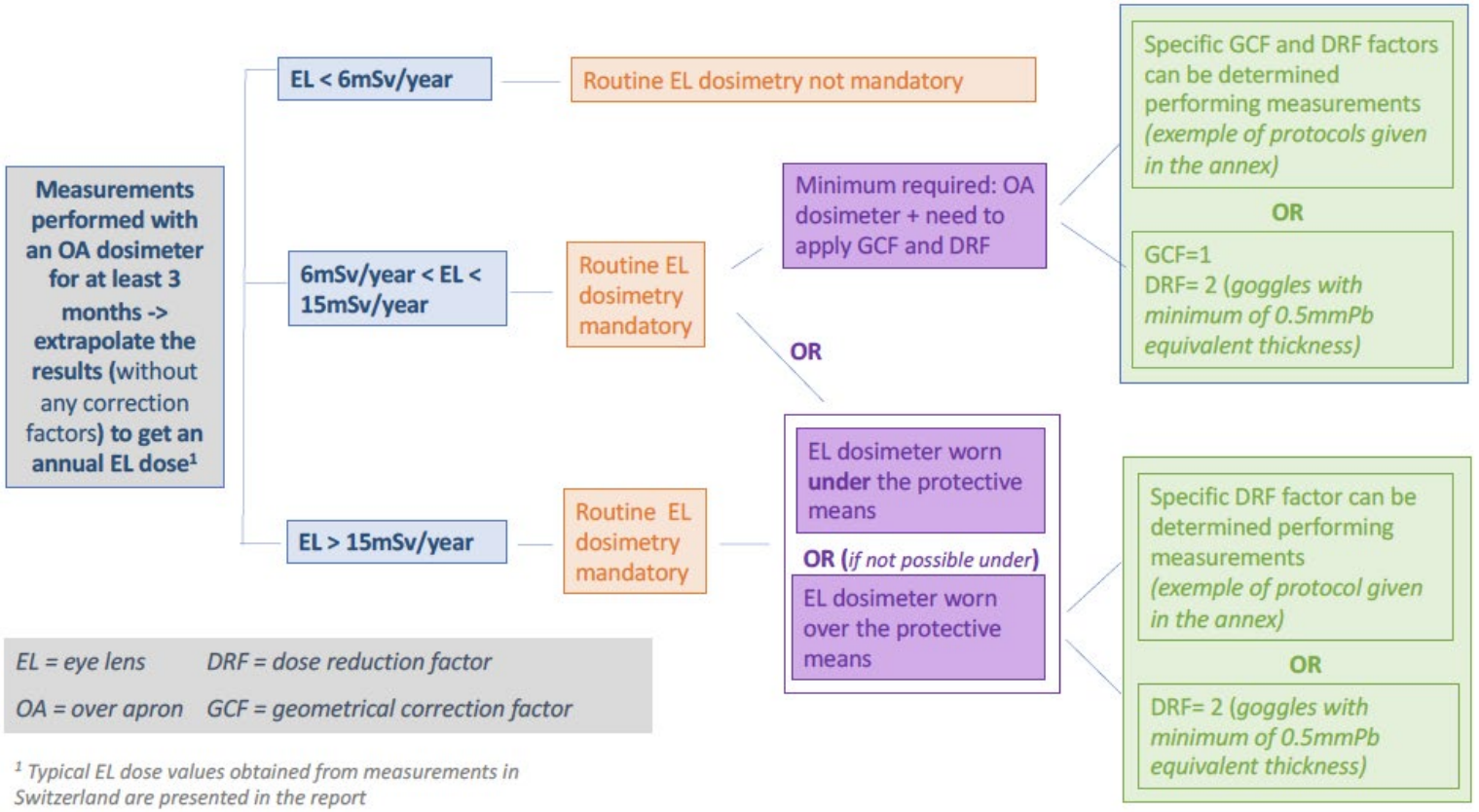
Summary of the working group's recommendations



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.

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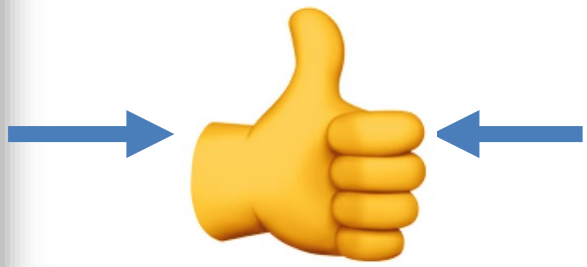

Thank you !