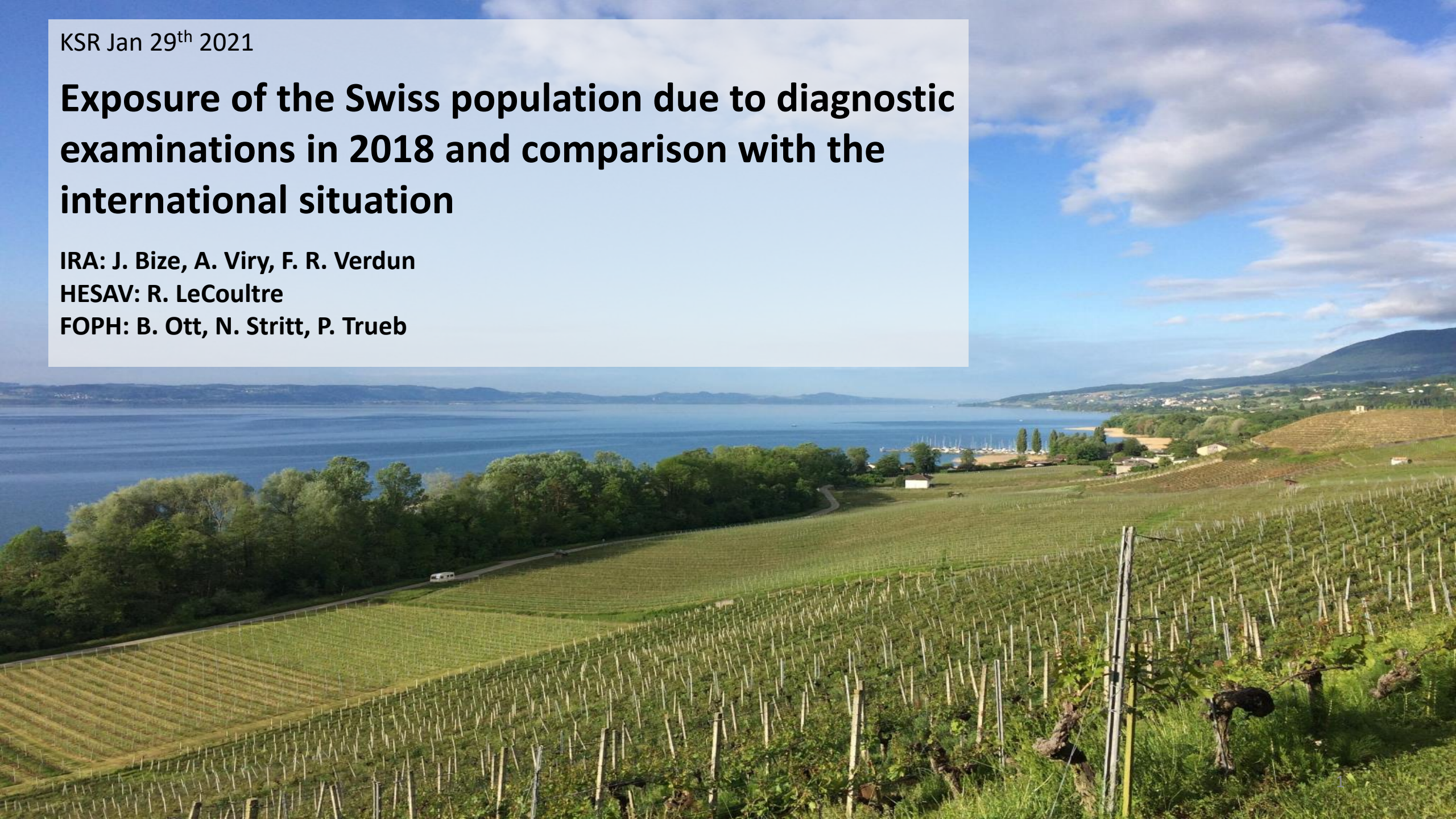# Exposure of the Swiss population due to diagnostic examinations in 2018 and comparison with the international situation

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General statement

- This work
  - was financially supported by the Swiss Federal Office of Public Health

  - is the result of scientific collaborations between IRA, HESAV, FOPH and several medical Societies

  - is part of a Swiss legal requirement aiming at assessing the impact of medical imaging on the exposure to the population

Introduction

- FOPH organizes every ten years an extensive survey to assess the practice of X-ray imaging in Switzerland (1998; 2008; 2018);

- Between those survey limited surveys are also organized with a limited sample (2003; 2013)

- All authorized practitioners using ionizing radiation have been contacted
  - Since 2008 the data are collected in-line

  - For this survey DACS data (Dosimetry Archiving and Communication System) have been used to improve the CT dose assessment

Participation rates

Practice	Contacted	Answered	Rate [%]
Chiro-practitioners	102	34	33.3
General practitioners	2765	860	31.1
Dentists without CBCT	2867	834	29.1
Dentists with CBCT	653	182	27.9
Radiologists	218	70	32.1
Nuclear medicine	51	48	94.1

- 4/5 University hospitals sent their invoice data; all provided their examinations' statistics
- All regional have been hospitals included
  - X-ray imaging participation rate → need for an extrapolation strategy
  - "Canton Vaud" as benchmark (10% population – rural/city practice)
    - Hypothesis : A national homogeneous ratio : X-ray imaging consultations/general medical consultations
  - Nuclear medicine participation rate → no need for an extrapolation strategy

Example for X-ray imaging

- Radiography
    - Use of a set of comprehensive set of data from the invoice coding registries
    - Ratio of the various radiography incidences
        - Frequency of radiological incidence vector, **F**
    - Use of standard effective dose per radiological incidence
        - Dose vector, **D**
    - From those data → an average effective dose per radiographic examination (E = **F** x **D**)

- CT
    - Similar approach but more complex since invoice code not directly related to standard examination nomenclature
    - Use actual effective dose delivered in actual centers
        - Use of DACS data mixture (Dosimetry Archiving and Communication System)
            - University hospitals and private practices
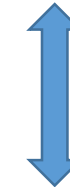
Nuclear medicine practice

- Examination frequency
  - Questioners
    - Prepared by radiographers then discussed within the SSMN board and adapted
    - Postal mail

  - Effective dose per examination
    - Injected activity
      - Used of Swiss DRL (Survey FOPM from 2019)
      - Less standard examinations: published data or actual injected activities
    - CT acquisition
      - Used of Swiss DRL (Survey FOPM; Lima et al. 2018)
      - Attenuation correction/higher image quality level

Nuclear medicine: frequency of the examinations in 2018

	Examination categories	Frequency/ 1000 capita	Part
Scintigraphies / SPECT ±CT	Bone	3.1	44%
	Thyroid	0.4	5%
	Parathyroid	0.2	2%
	Pulmonary perfusion	0.3	5%
	Pulmonary ventilation	0.2	2%
	Heart	2.0	28%
	Kidney	0.3	4%
	Brain	0.006	0.08%
	Meckel diverticula	0.001	0.02%
	Haemorrhage	0.003	0.05%
	Inflammation	0.012	0.16%
	Lymph node scintigraphy	0.7	9%
		7.2	54%
PET/CT	PET tumour	5.9	97%
	PET heart	0.2	3%
	PET brain	0.04	1%
		6.1	46%
Total		13.3	100%
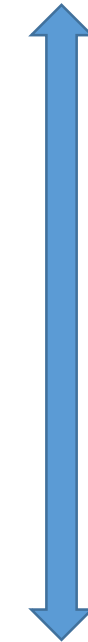
100%

100%

Nuclear medicine: Frequency contributions per technique

		Frequency part		Hybrid techniques	
		Frequency/ 1000 capita	Percentage	Frequency/ 1000 capita	Percentage
Scintigraphies / SPECT ±CT		7.2 (including 2.4)	54.2%	2.4	18.1%
PET/CT	CT (attenuation correction)	4.0	30.3%		
	CT (diagnostic quality)	2.1	15.5%		
	Subtotal	*13.3*	*100.0%*		
	Total	**13.3**			

Nuclear medicine part

Frequency

Labels (clockwise): Diverticule de Meckel, Source hemorragie, Cerveau, inflammation, PET Cerveau, PET Coeur, Parathyroide, Ventilation pulmonaire, Reins, Perfusion pulmonaire, Thyroide, Lymphoscintigraphie, Myocarde, Systeme osseux, PET Tumeur

Exposure

Labels (clockwise): Diverticule de Meckel, Source hemorragie, Cerveau, Inflammation, Ventilation pulmonaire, PET Cerveau, Reins, PET Coeur, Thyroide, Perfusion pulmonaire, Parathyroide, Lymphoscintigraphie, Systeme osseux, Myocarde, PET Tumeurs

	CH 2010	**FR 2012**	**US 2016**	**FR 2017**	**CH 2018**
Effective dose per caput. [mSv]	**0.060**	0.120	0.320	0.174	**0.107**

X-ray imaging frequencies in 2018

Conventional radiography

Anatomical part	Frequency for 1000 inhabitants	Percentages
Head	4	0.8%
Chest	115	26.1%
Abdomen	9	2.1%
Pelvis / Hips	56	12.7%
Extremities	219	49.8%
Lumbar spine	37	8.3%
Total	**439**	**100.0%**

Dental radiography

Dental radiography	Frequency for 1000 inhabitants	Percentages
Projection radiography	489.6	83%
Panoramic view : OPG	94.4	16%
3D - CBCT	4.7	~ 1%
Total	**588.7**	**100.0%**

Computed tomography

Anatomical part	Frequency for 1000 inhabitants	Percentages
Brain	19.0	14.1%
Face / Sinus	5.3	3.9%
Dental	0.2	0.2%
Neck	7.7	5.7%
Chest	15.9	11.8%
Abdomen	23.9	17.7%
Chest + Abdomen combined	22.1	16.4%
Pelvis	10.6	7.9%
Lumbar spine	15.9	11.8%
Shoulder	1.1	0.8%
Arm - Elbow	0.6	0.4%
Wrist - hand	1.3	1.0%
Hips	3.6	2.6%
Knee - Leg	4.3	3.2%
Ankle - foot	3.4	2.5%
Total	**135.0**	**100.0%**

Summary of the results

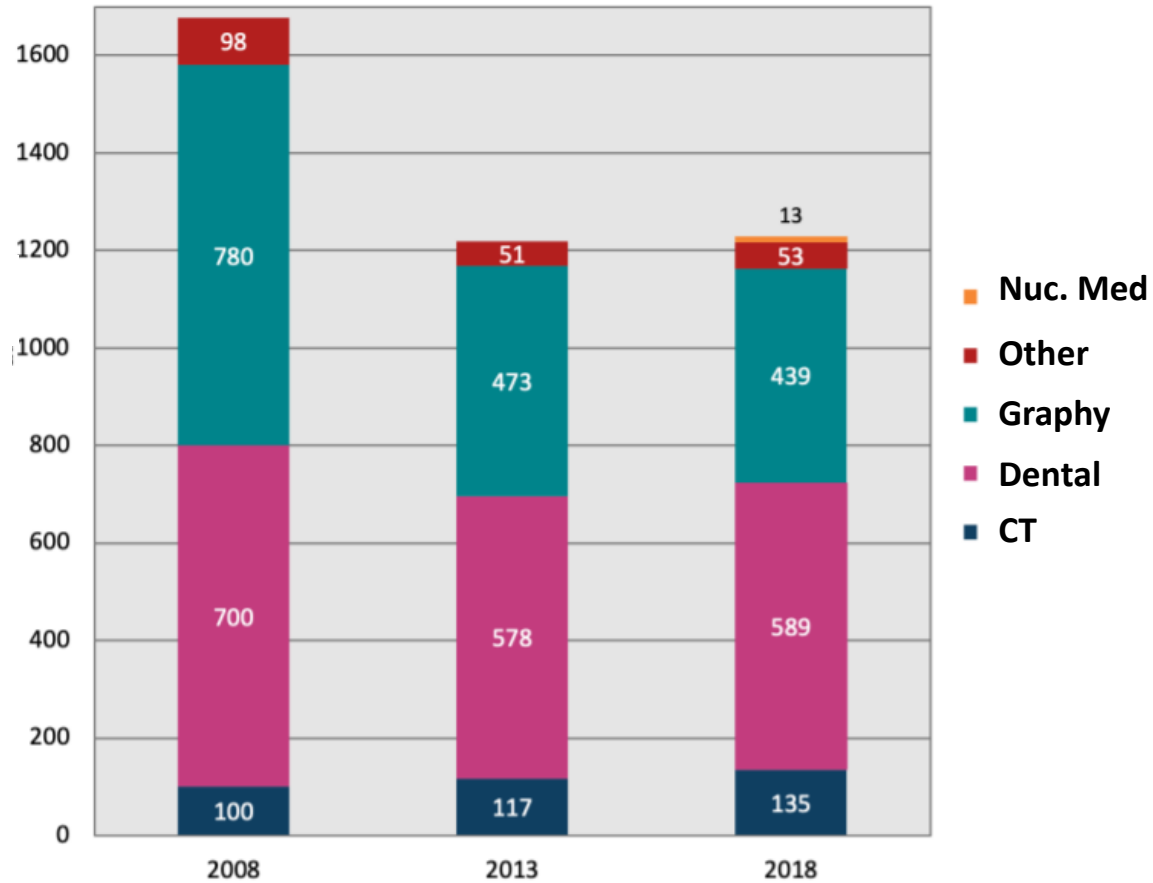Frequency of X-ray medical examinations (including Nuclear Medicine)
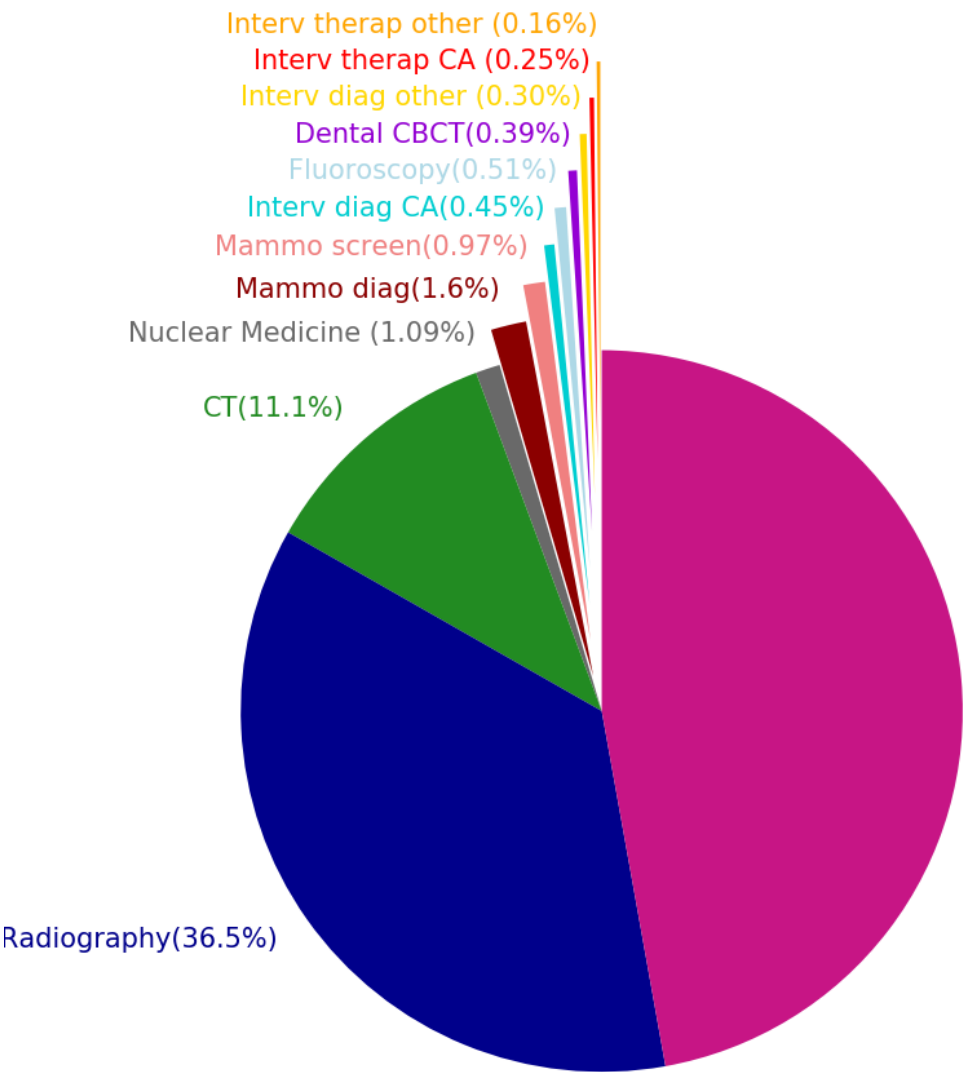
Dose contribution of X-ray medical examinations (including Nuclear Medicine)
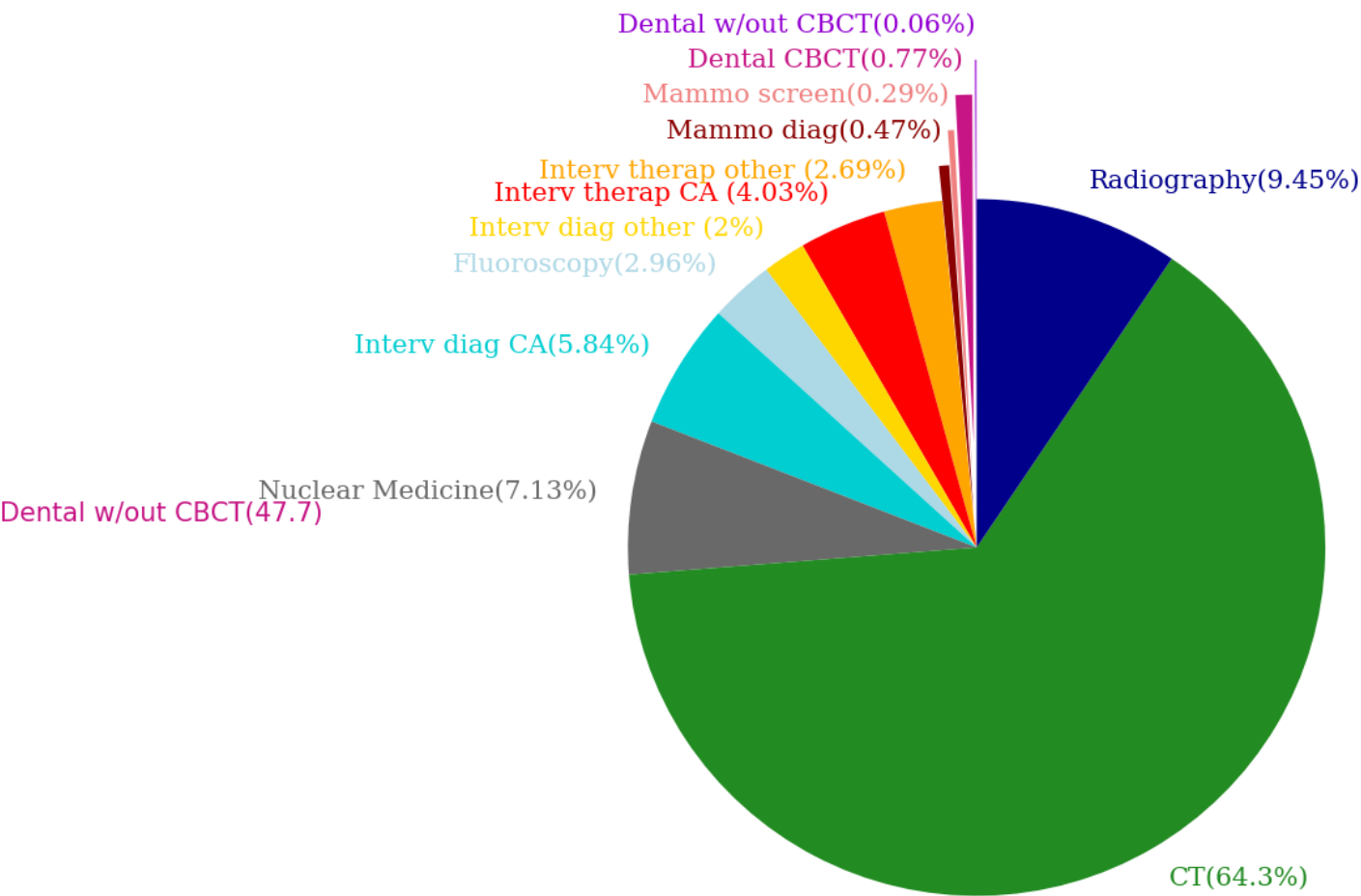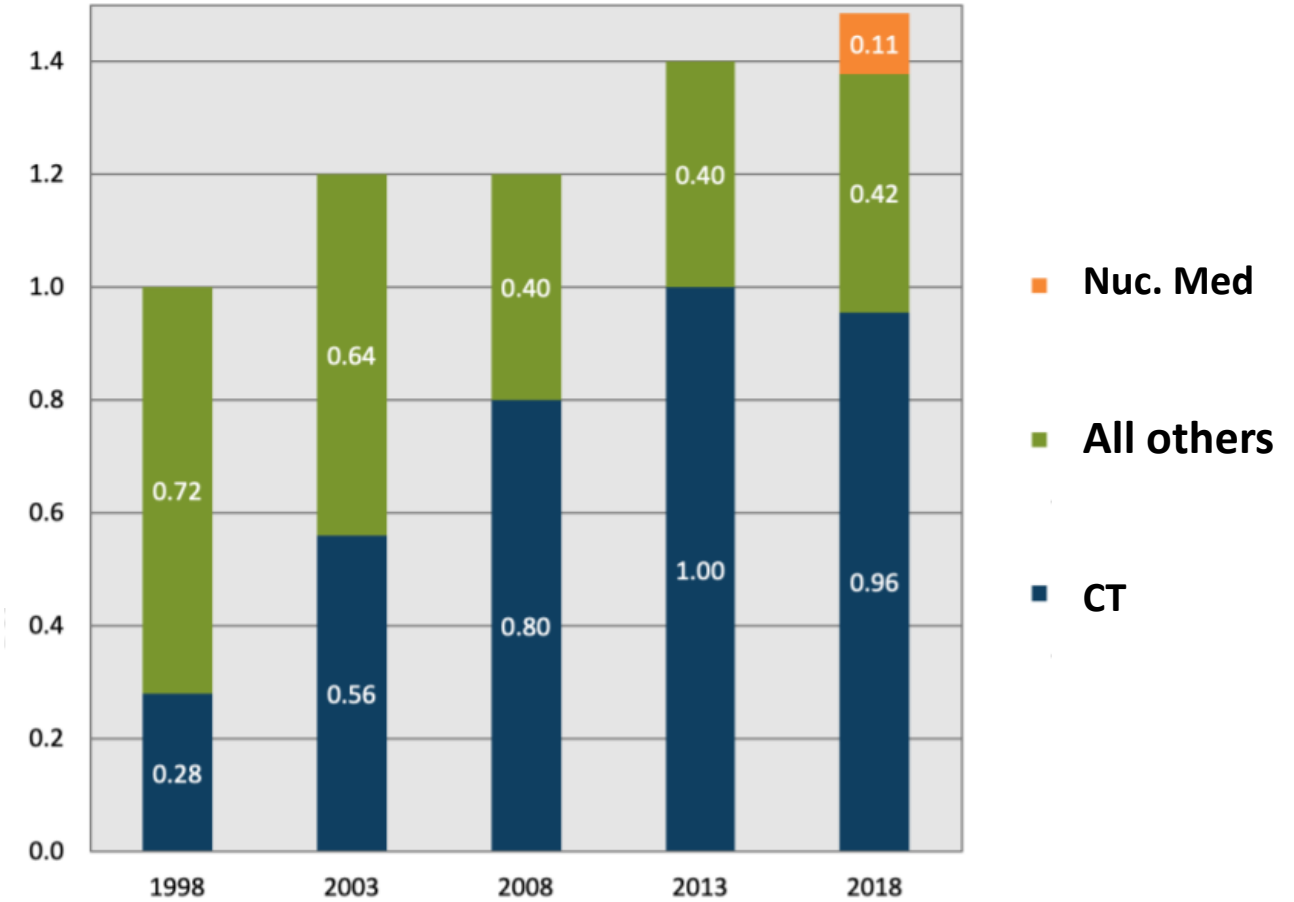
Trend over time

Examinations per 1000 inhabitants

Legend: Nuc. Med, Other, Graphy, Dental, CT

2008: CT 100, Dental 700, Graphy 780, Other 98
2013: CT 117, Dental 578, Graphy 473, Other 51
2018: CT 135, Dental 589, Graphy 439, Other 53, Nuc. Med 13

Effective dose (mSv) per inhabitant

Legend: Nuc. Med, All others, CT

1998: CT 0.28, All others 0.72
2003: CT 0.56, All others 0.64
2008: CT 0.80, All others 0.40
2013: CT 1.00, All others 0.40
2018: CT 0.96, All others 0.42, Nuc. Med 0.11

Comparison with other international surveys

- ## X-ray imaging

	CH 2008	FR 2012	CH 2013	DE 2014	AT 2015	US 2016	FR 2017	CH 2018
Radiography and radioscopy	0.36	0.34	0.41	0.60	*	0.47	0.22	0.41
Dental radiology	0.01	0.003	0.01	0.01	*	0.04	0.004	0.013
CT	0.80	1.14	1.00	1.00	1.10	1.32	1.14	0.956
Total excluding Nuc Med	1.20	1.47	1.42	1.61	*	1.84	1.36	1.38

	US 2006	DE 2007	CH 2008	FR 2012	CH 2013	DE 2014	AT 2015	US 2016	FR 2017	CH 2018
CT examinations for 1000 inhabitants	206	100	101	104	117	~140	166	~222	152	135 (160)*

*) without anatomical parts combinations

- ## Nuclear Medicine

	CH 2010	FR 2012	US 2016	FR 2017	CH 2018
Effective dose per caput. [mSv]	0.060	0.120	0.320	0.174	0.107

Use of the invoice data set

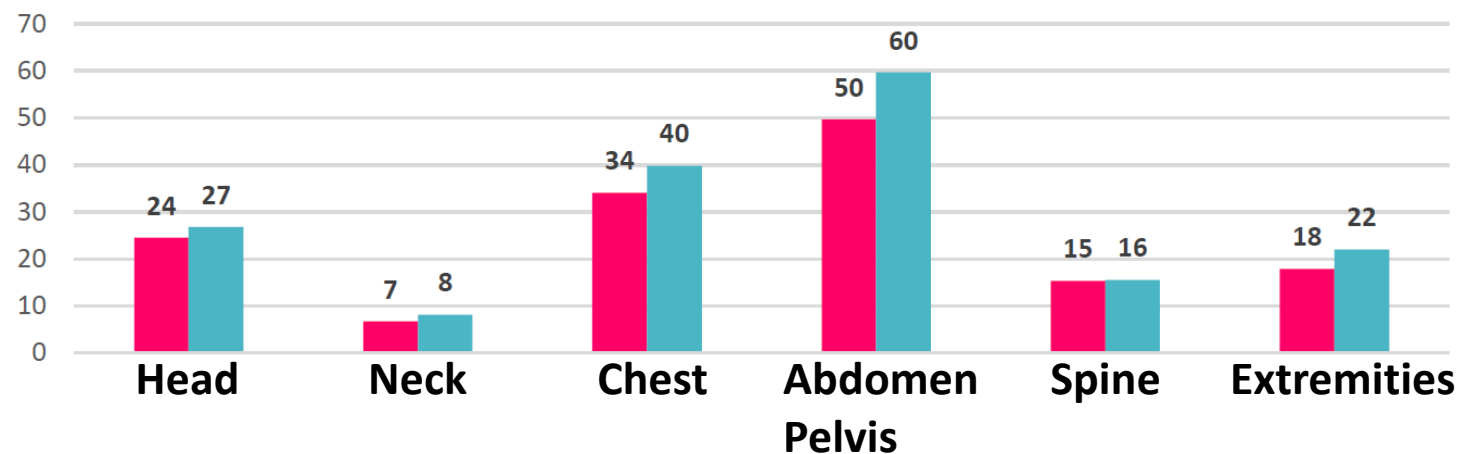| Age categories	General population 2018	Population exposed to radiography	Population exposed to CT
0 - 19	20%	14% (- 6%)	3% (-17%)
20 - 64	62%	48% (-14%)	47% (-15%)
≥ 65	19%	37% (+18%)	50% (+31%)
Median value	42.8	55.5	65.5

CT versus age
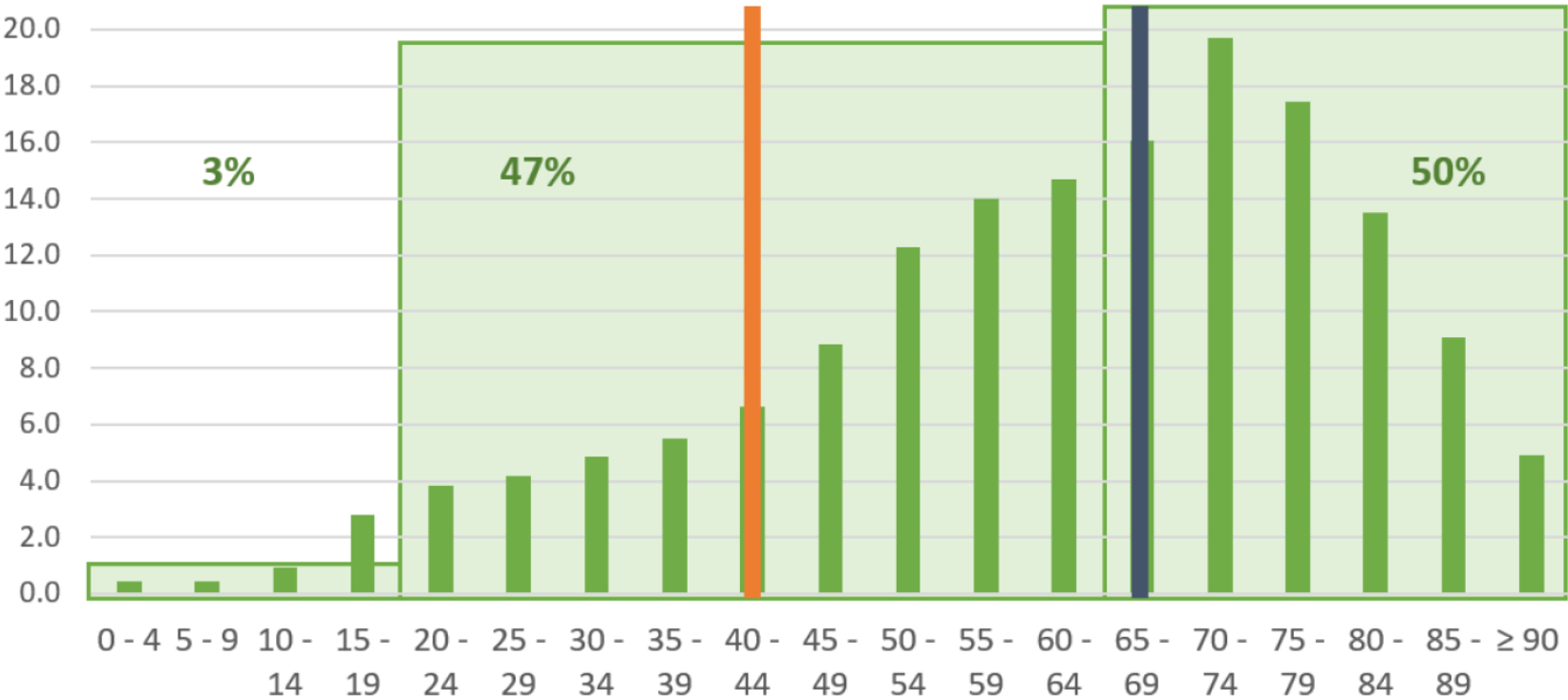
Use of the invoice data set

CT examination women / men (for 1000 women and 1000 men)
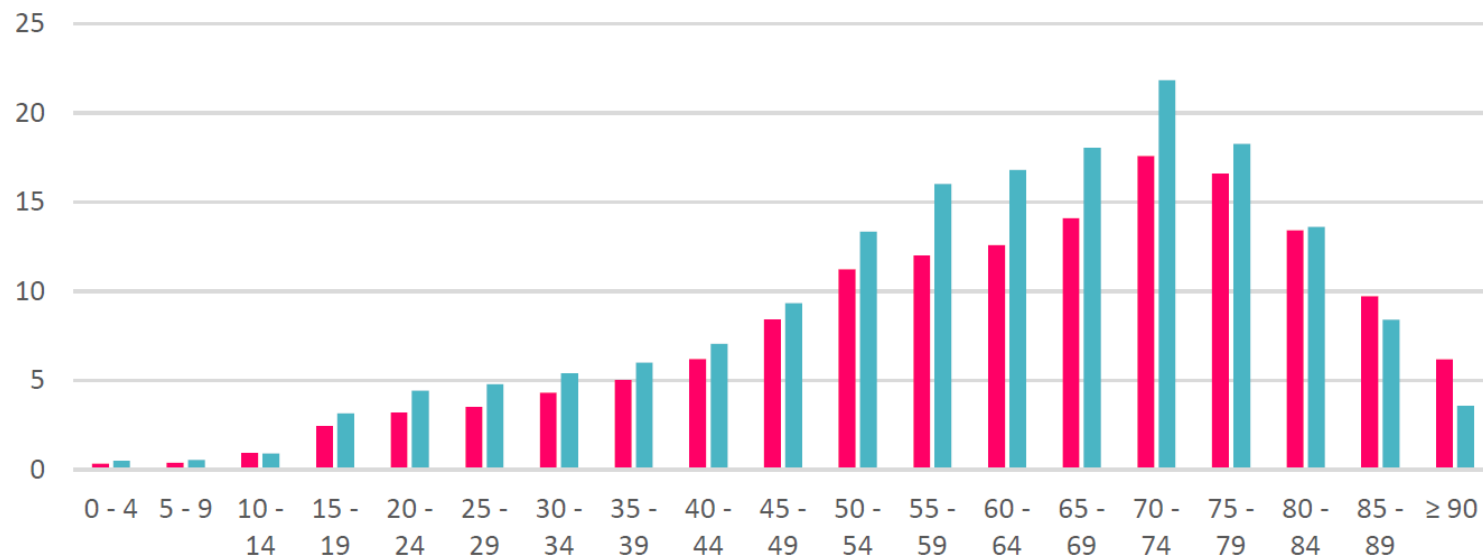
CT examination per anatomical region

Conclusion

- X-ray imaging from 2013 to 2018
  - Tarmed coverage: almost complete for « Canton de Vaud »
    - Could be used to monitor trends over time
    - Could allow repeated examinations assessment over a given year

  - Better CT dose estimation (DACS)
    - CT : 15% increase in frequency but no major impact on population exposure
      - Iterative reconstruction and protocol optimization
  - 1.38 mSv for 1216 examinations/1000 inhabitants
    - Value compatible with other European countries

- Nuclear medicine
  - Last survey in 2010
    - 0.06 mSv for 12.3 examinations/1000 inhabitants
  - Synchronized with X-ray imaging survey
    - 0.107 mSv for 13.3 examinations/1000 inhabitants
      - Value compatible with other European countries