UNSCEAR
United Nations Scientific Committee on the Effects of Atomic Radiation

UN environment programme

UNSCEAR's new evaluations on medical and occupational exposure to ionizing radiation

UNSCEAR 2020/2021 Report, annex A and annex D

Jing Chen

Chair of UNSCEAR (69th and 70th Sessions)

European Summer School 2024

Université franco-allemande
Deutsch-Französische Hochschule

"Radiation Measurements & Radiochemistry in Environment & Decommissioning"

Strasbourg, France, July 1 - 5, 2024

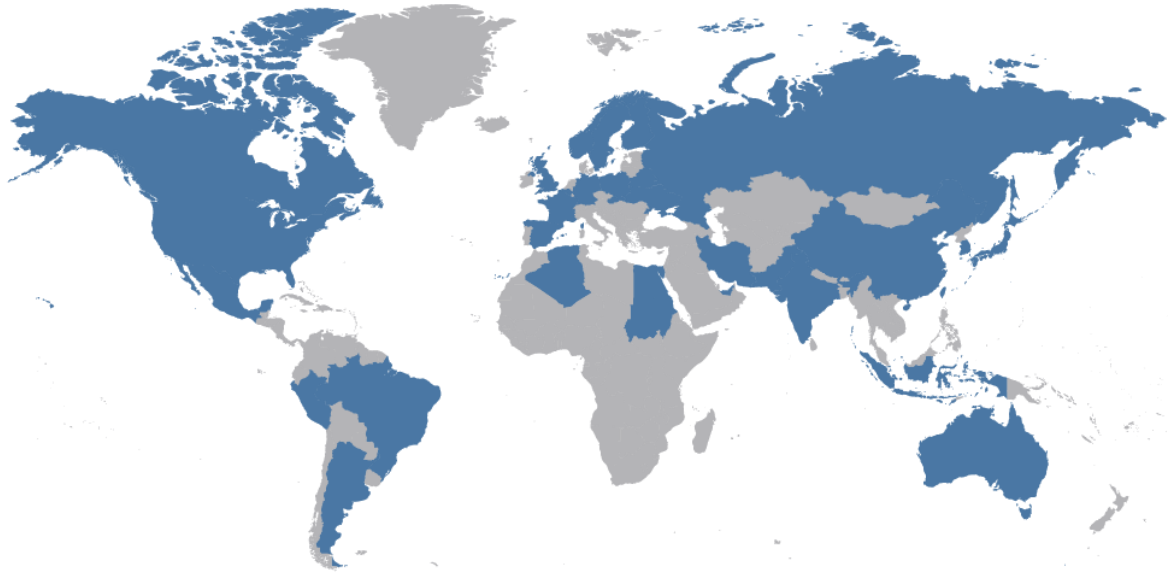
Background

UNSCEAR was established in 1955 by the UN General Assembly Resolution with the mandate

- To evaluate the latest scientific data on levels, effects and risks of exposure to ionizing radiation on humans and the environment for Member States, scientific community & the public
- To provide independent, objective and up-to-date scientific basis for radiation safety
- to disseminate findings to the General Assembly, to scientific community and to the public.

UNSCEAR members: scientists from 31 UN Member States

- Algeria
- Argentina
- Australia
- Belarus
- Belgium
- Brazil
- Canada
- China
- Egypt
- Finland
- France
- Germany
- India
- Indonesia
- Iran (IR)
- Japan
- Mexico
- Norway
- Pakistan
- Peru
- Poland
- Rep. of Korea
- Russia
- Slovakia
- Spain
- Sudan
- Sweden
- Ukraine
- UAE
- UK
- USA



Other Member States and international organizations provide relevant data

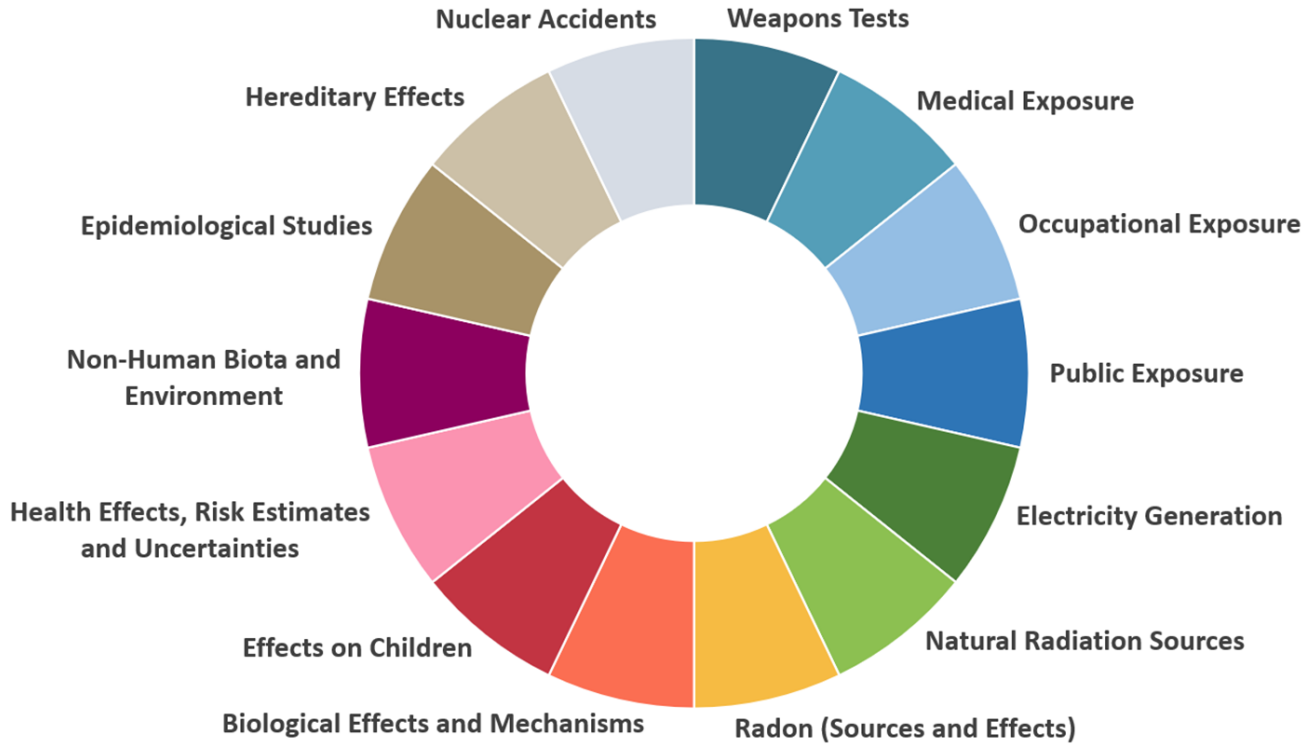
1955	1974	1986	2011	2022
15	20	21	27	31

Background

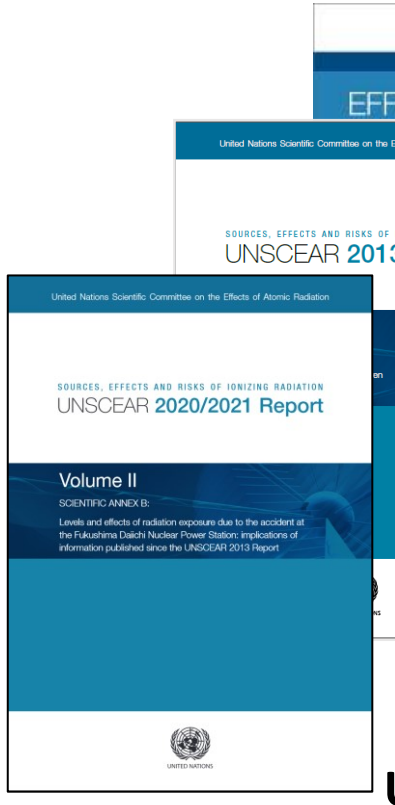
In the past 68 years, UNSCEAR has published
113 scientific annexes, 1 summary report and 5 white papers.

All reports and publications are available on UNSCEAR website for free download.

www.unscear.org

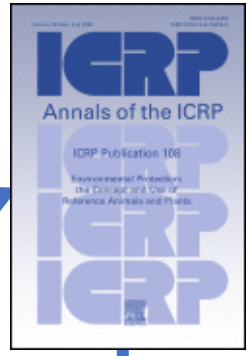


International Radiation Safety Regime



UNSCEAR
Scientific basis

Issues
effects
risks



ICRP
Protection philosophy, principles and units

Recommendations

Issues
levels
trends

***IAEA** Safety Standards*
Implemented by UN Member States

ILO convention:
occupational
radiation protection

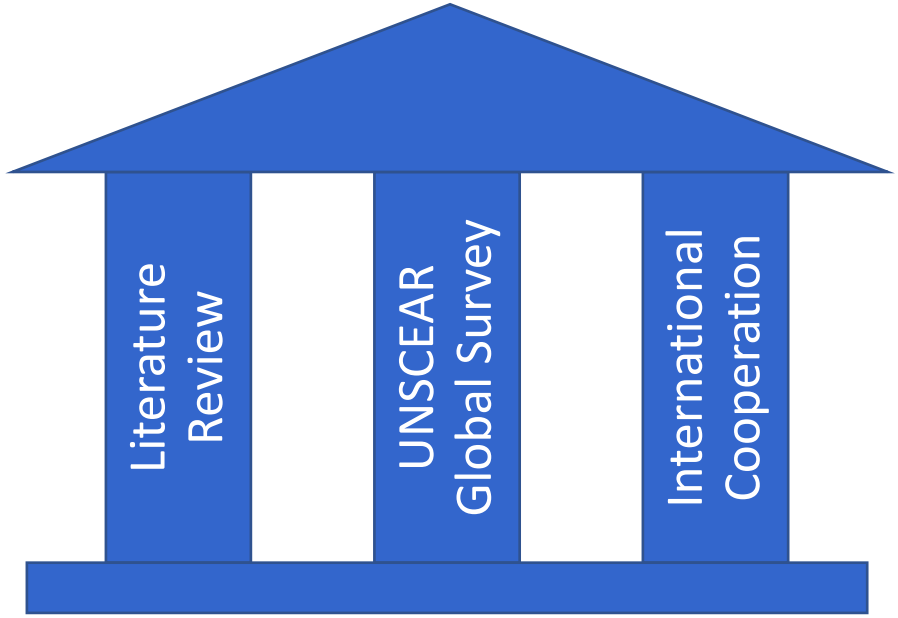
FAO/WHO
Codex Alimentarius Commission
(food contamination guides)

UN transport regulations for
radioactive material

UNSCEAR data collection and data sources

- Peer reviewed literature
- Data from national contact persons through the UNSCEAR global survey

United Nations Scientific Committee on the Effects of Atomic Radiation
survey.unscear.org

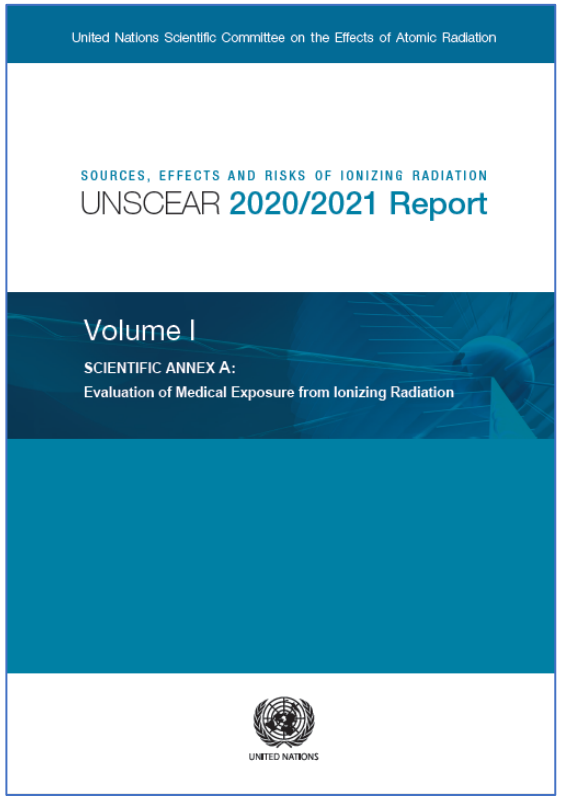


- Cooperation with other International Organizations such as:

  CTBTO, EC, IAEA, ICAO, ILO, IMO, NEA/OECD, UNOOSA, WHO, WMO

Evaluation of medical exposure to ionizing radiation

UNSCEAR 2020/2021 Report, annex A



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SOURCE OF DATA

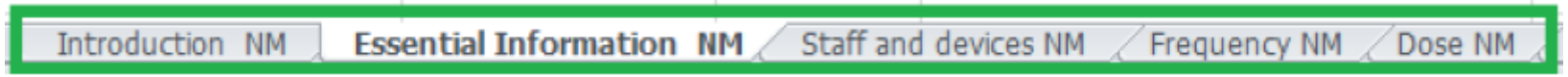
UNSCEAR Global Survey of Medical Exposure (launched in 2014):

All UN Member States were invited to provide the Committee with relevant data about frequency and doses from various medical radiological examinations;

The UNSCEAR secretariat established an online platform and a network of National Contact Persons to collect information from UN Member States through online questionnaires.

- Spreadsheet questionnaires

  Diagnostic radiology – including interventional radiology, nuclear medicine and radiation therapy



- Each questionnaire

  Introduction, essential information, staff and devices, frequency, dose

- Doses in relevant “practical” quantities

  (e.g. entrance surface air kerma, kerma-area product, volume computed tomography dose index, administered activity, etc.)

Examinations/Procedures - Radiology

Essential

Information on frequency of radiological examinations (simplified)

* required field

Modality category	Number of examinations	Uncertainty (%)
All radiological examinations*		
Radiography and fluoroscopy (without Dental)		
Dental radiography		
Computed Tomography (CT)		
Image-guided interventional procedures (IGIP)		

Information on staffing (simplified)

* required field

Profession	Number of persons
All physicians*	
Dentists	
Radiologists	

Information on radiology devices (simplified)

* required field

Radiological system	Number of devices
All radiographic systems*	
Dental X-ray systems	
Computed Tomography (CT)*	

Detailed

Information on frequencies of radiological examinations

Modality category	Examination category
Projection radiography (without contrast media)	**Total projection radiography**
	Head (skull & facial bones)
	Head (soft tissue)
	Neck (cervical spine)
	Neck (soft tissue)
	Chest/Thorax (lungs PA & LAT)
	Chest (thoracic spine)
	Chest (shoulder girdle & ribs)
	Mammography
	Mammography (screening)
	Lumbar spine
	Lumbo-sacral joint only
	Abdomen
	Pelvis & hips (bone)
	Pelvis (soft tissue)
	Limbs and joints
	Whole spine (trunk)
	Skeletal survey (head & trunk)
	Dental intraoral
	Dental panoramic

Literature review

- Comprehensive review of articles published 2005-2018 (inclusive)
- Search terms
  - population dose, collective effective dose (medical), frequencies of examinations, procedures or treatments (radiology, nuclear medicine and radiation therapy), examination codes, patient dose and radiology, automatic dose management.
- Screened to identify publications demonstrating changes and updates in practice since the UNSCEAR 2008 Report
- Some additional recent relevant articles included
- 640 articles identified for review, 373 assessed as meeting the criteria for inclusion in this evaluation
- Literature discussed in details in appendices B-E

SOURCE OF DATA

- UNSCEAR Global Survey of Medical Exposure:

United Nations Scientific Committee on the Effects of Atomic Radiation
survey.unscear.org

- Information and data from the literature after a review process by the Expert Group
- Additional supporting data directly from other sources such IAEA[1,2], WHO, OECD/NEA and EC

IAEA International Atomic Energy Agency

World Health Organization

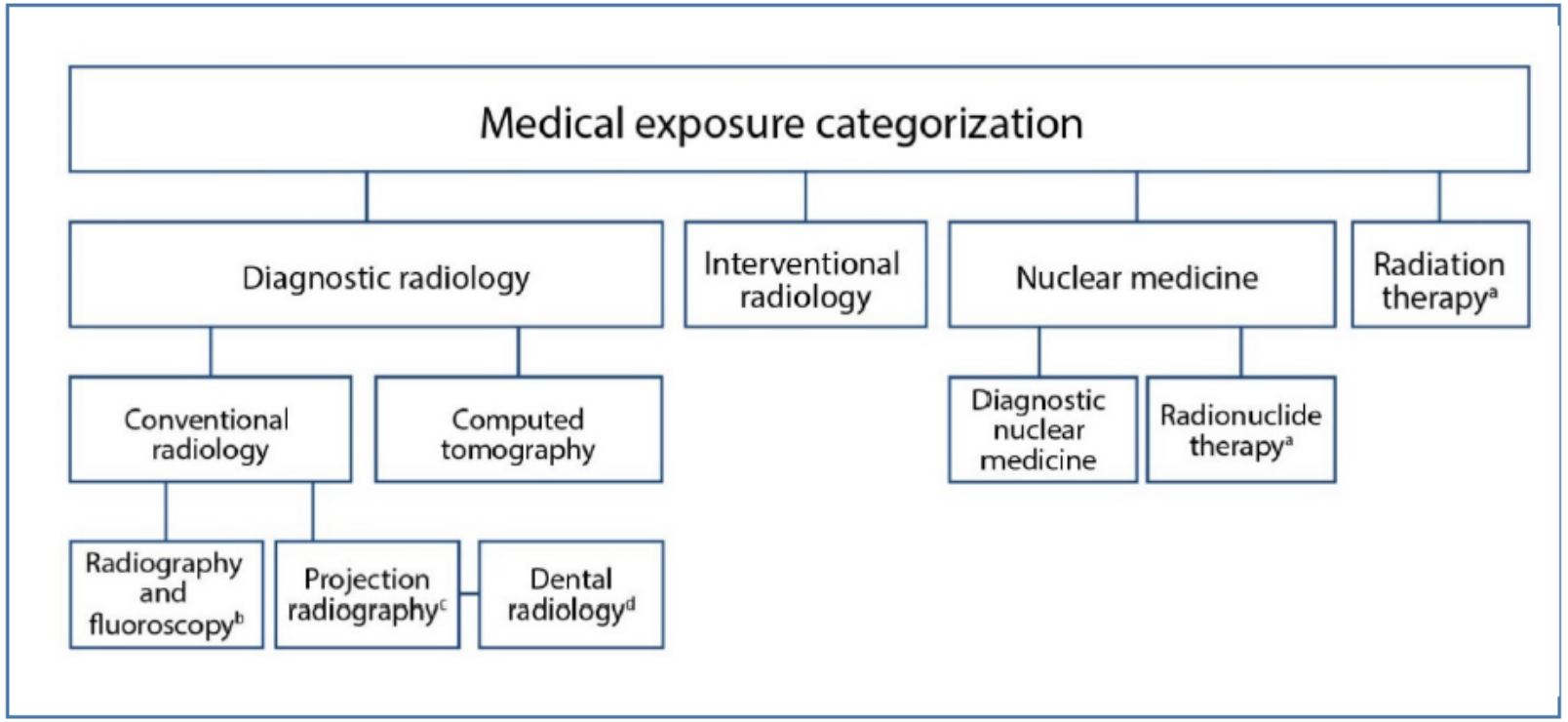
NEA NUCLEAR ENERGY AGENCY

European Commission

1 NUclear Medicine DAtaBase

2 DIrectory of RAdiotherapy Centres

Modality categorization used by UNSCEAR



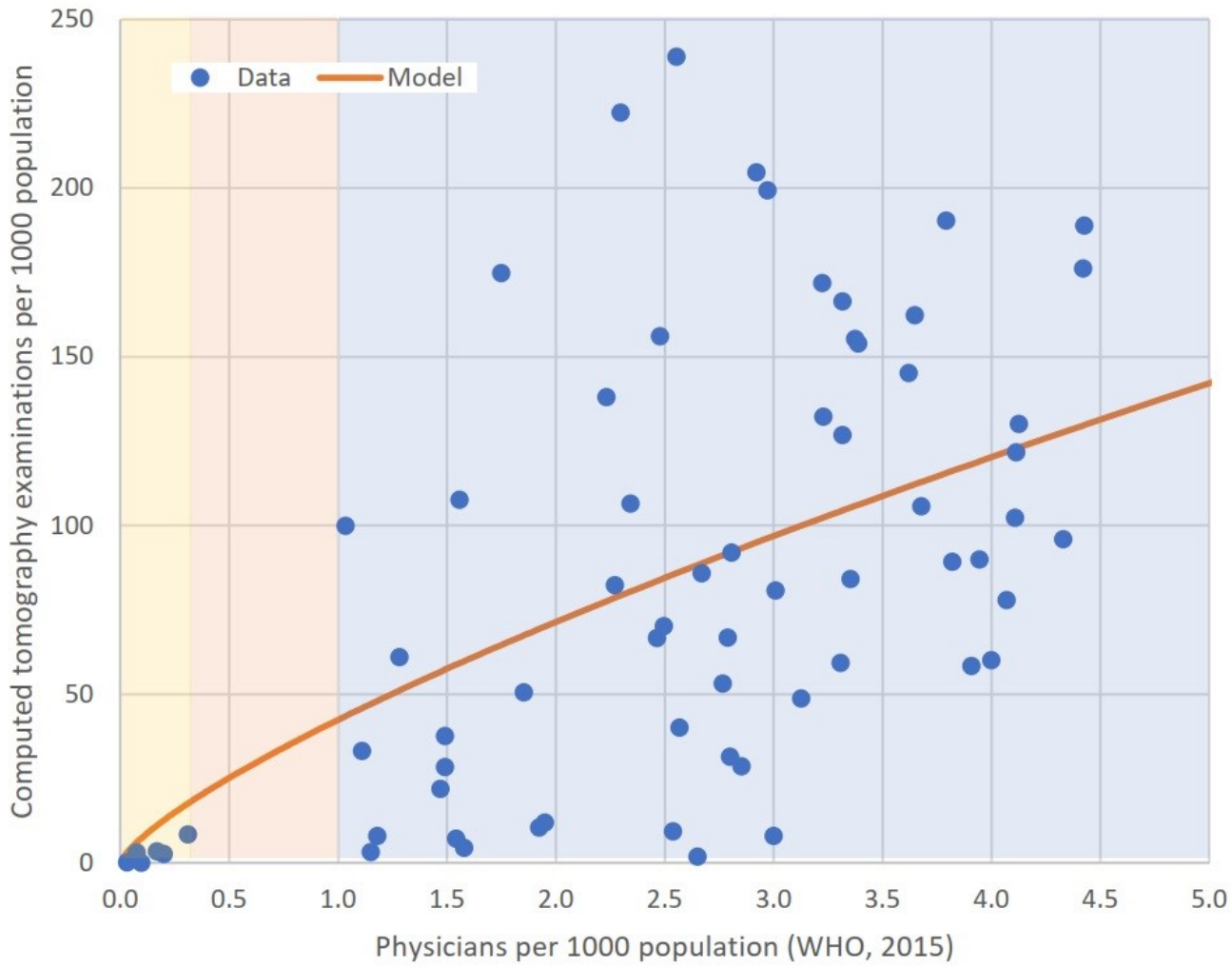
[a] Not part of the collective effective dose assessment because such therapeutic doses are intentionally high enough to cause deterministic effects, however, included in the frequency trend analyses.

[b] Mostly with contrast media.

[c] Without contrast media.

[d] Analysed separately for the global assessment.

Medical Exposure



Continuous models

- Separate models for 7 broad modality categories
- Frequency (examinations per 1000 population) as a function of physician density (doctors per 1,000 population)
- We have widely available data on physician density from WHO.
- Power law as a function of physician density [WHO, 2015])

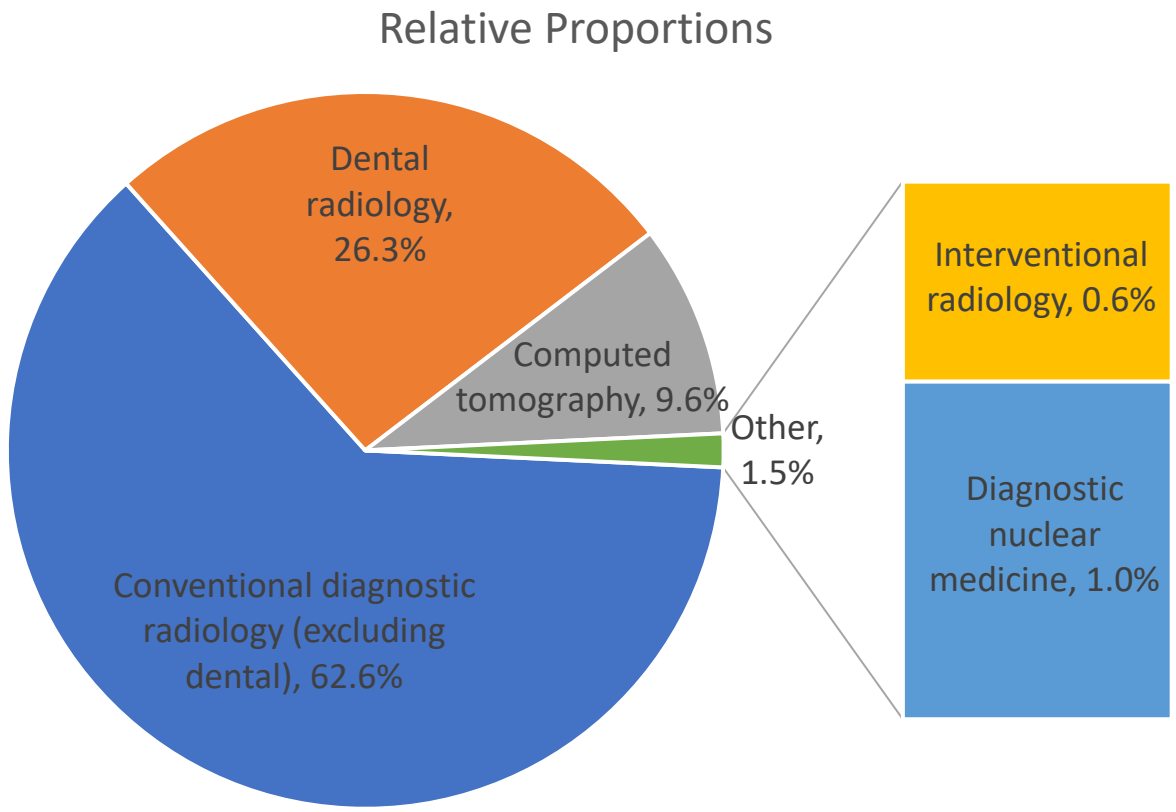
$$F = a * (\text{physician density})^b + \varepsilon$$

- Used to estimate examination frequency for Member States where no data was available

Medical Exposure

Examinations / Procedures

Category	Examinations (millions)[a]	Uncertainty (%)
Conventional radiology (excluding dental)	2630	35
Dental radiology	1100	60
Computed tomography	400	40
Interventional radiology	24	80
Diagnostic nuclear medicine	40	70
Radionuclide therapy[b]	1.4	35
Radiation therapy[b]	6.2	25
Total	**4190**	**30**



[a] Values have been rounded

[b] Counts for radionuclide therapy and radiation therapy not included in the total

Dose per examination or procedure

Category	Frequency-weighted effective dose per examination/procedure (mSv)
Conventional radiology (excluding dental)	0.37 (0.39[a])
Dental radiology	0.01
Computed tomography	6.4
Interventional radiology	15
Diagnostic nuclear medicine	6.8 (5.1[b])
All	**0.99**

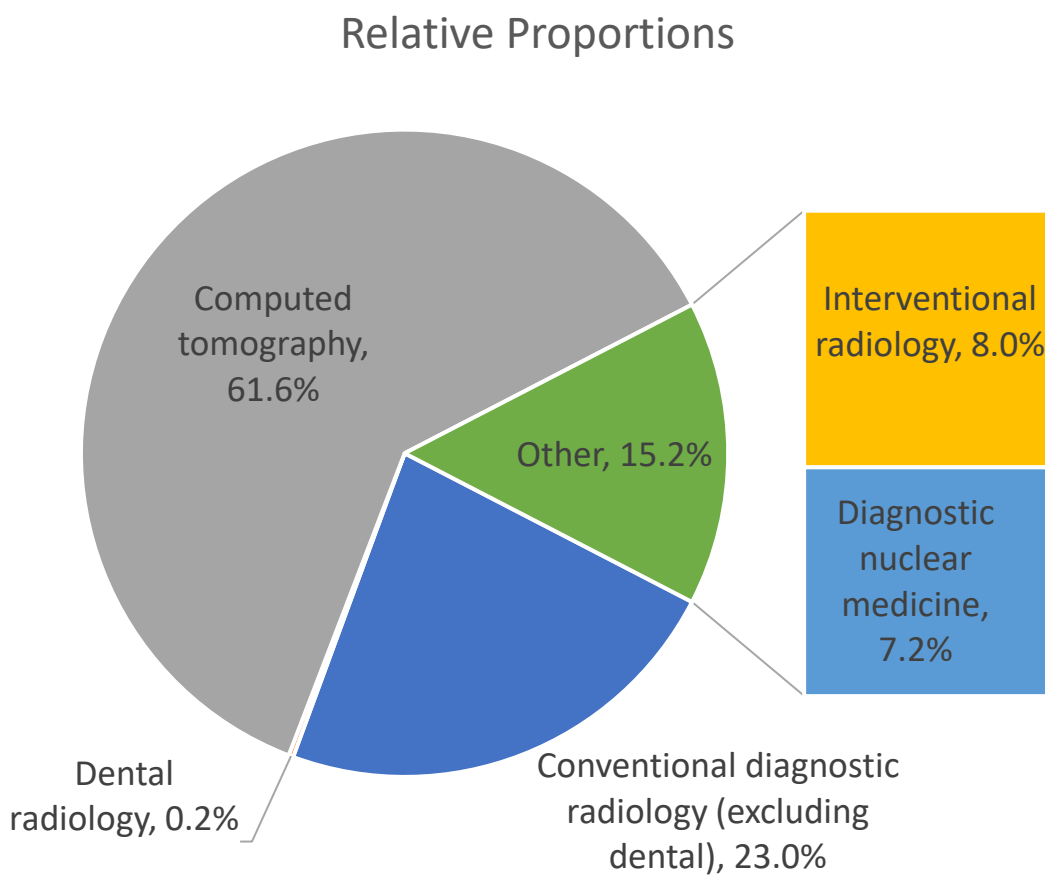
- Survey data used for dose estimates for Member States providing data (~30 countries)
- Practical dose quantities with a conversion factor to estimate effective dose preferred
- Frequency-weighted average dose per procedure from survey data used for Member States not providing data

a Alternative value of 0.39 mSv per examination for Member States in HCL II-IV assumed to have a low level of mammography examinations
b Alternative value of 5.1 mSv per procedure for Member States having no PET equipment and assumed not to be conducting PET procedures

Collective Effective Dose

Category	Collective effective dose (1000 man Sv)[a]	Uncertainty (%)
Conventional radiology (excluding dental)	950	45
Dental radiology	10	70
Computed tomography	2560	45
Interventional radiology	330	90
Diagnostic nuclear medicine	300	75
Total	**4150**	**30**

[a] Values have been rounded



Comparison with UNSCEAR 2008 Assessment

UNSCEAR 2008 Assessment

Category	Examinations (millions)	Collective eff. dose (1000 man-Sv)
Conventional radiology (excluding dental)	2900	2350
Dental radiology	480	11
Computed tomography	220	1540
Interventional radiology	3.6	41
Diagnostic nuclear medicine	33	202
All	**3660**	**4210**

UNSCEAR 2020/2021 Assessment

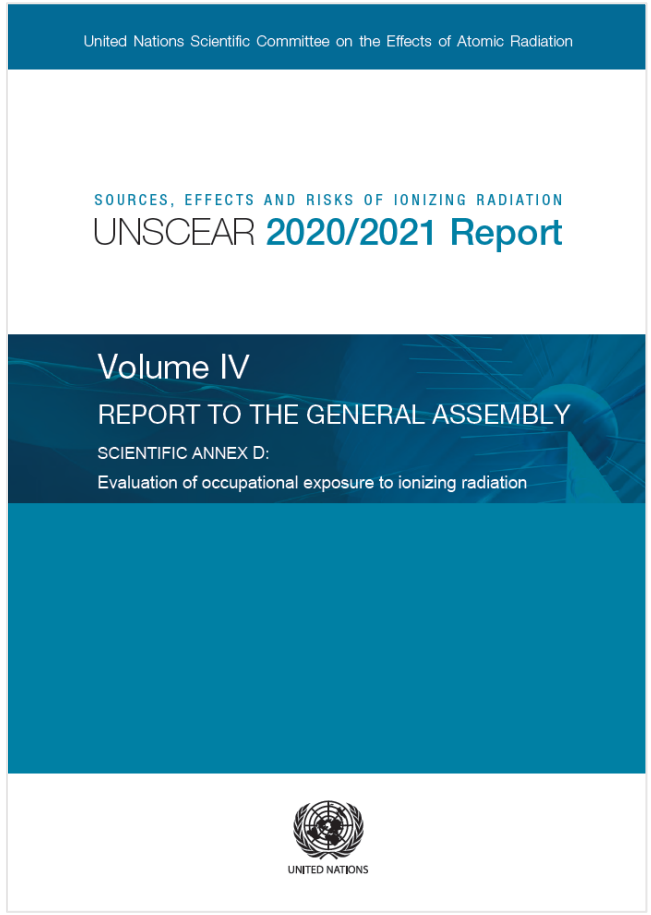
Category	Examinations (millions)	Collective eff. dose (1000 man-Sv)
Conventional radiology (excluding dental)	2630	950
Dental radiology	1100	10
Computed tomography	400	2560
Interventional radiology	24	330
Diagnostic nuclear medicine	40	300
All	**4190**	**4150**

Summary of the 2020/2021 assessment

- Medical exposures remain the largest contributor to radiation exposure of the population from artificial sources.
- Estimated 4.2 billion (±30%) examinations per year worldwide.
- Estimated annual collective effective dose of 4.2 million (±30%) man-Sv.
- Estimated global annual effective dose of 0.57 mSv per caput.
- Estimate derived from a continuous model, not extrapolation of survey data within health-care level categories.
- Computer tomography accounts for 62% of the collective effective dose but only 10% of the total number of examinations.
- Interventional radiology now estimated to account for 8% of the collective effective dose, a significant increase from 1% in 2008.

Evaluation of occupational exposure to ionizing radiation

UNSCEAR 2020/2021 Report, annex D



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Scope and Objective of the Evaluation

- To assess average annual effective doses and collective doses to workers for work sectors and subsectors
- To estimate the worldwide level of occupational exposure for different sectors involving exposure to natural and human-made sources of radiation
- To identify and analyze trends in occupational exposure
- To identify possible new groups of workers receiving higher doses
- To address the level of exposure to the lens of the eye
- To identify research needs, and implications for future analysis

Dose assessment methodology

- Operational quantities as defined by ICRU
- Assessment of effective dose
  - Exposure from external sources of radiation
    - Including cosmic radiation
  - Exposure from intake of radionuclides
    - Including radon inhalation
- Equivalent dose
  - Lens of eye

Challenges Using Data in the Evaluation of Occupational Exposure

- Comparing exposure data between countries
  - Differences in protocols for monitoring and reporting
  - Type of dosimetry technique and detection limit
  - Formatting responses (different exposure intervals)
  - Whether internal exposure included or assessed separately
  - Accounting for not measurably exposed workers
  - Accounting for transient (temporary) workers
- Incomplete data sets

Sources of Ionizing Radiation

- Natural sources of radiation
  - Cosmic ray exposure of aircrew and space crew
  - Exposure in extractive and processing industries
  - Exposure from oil and natural gas extraction industry
  - Radon exposure in workplaces other than mines
- Human-made sources of radiation
  - Nuclear fuel cycle
  - Medical uses of radiation
  - Industrial uses of radiation
  - Military uses
  - Miscellaneous uses of radiation

Occupational Exposure

- About 12 million workers in mining operations
- Levels of exposure have decreased over time
- Majority of workers not individually monitored
- No evaluation conducted for gas and oil extraction and for radon at workplaces other than mines due to lack of data
- Values underestimated, since oil&gas extraction and radon in many workplaces are not included.

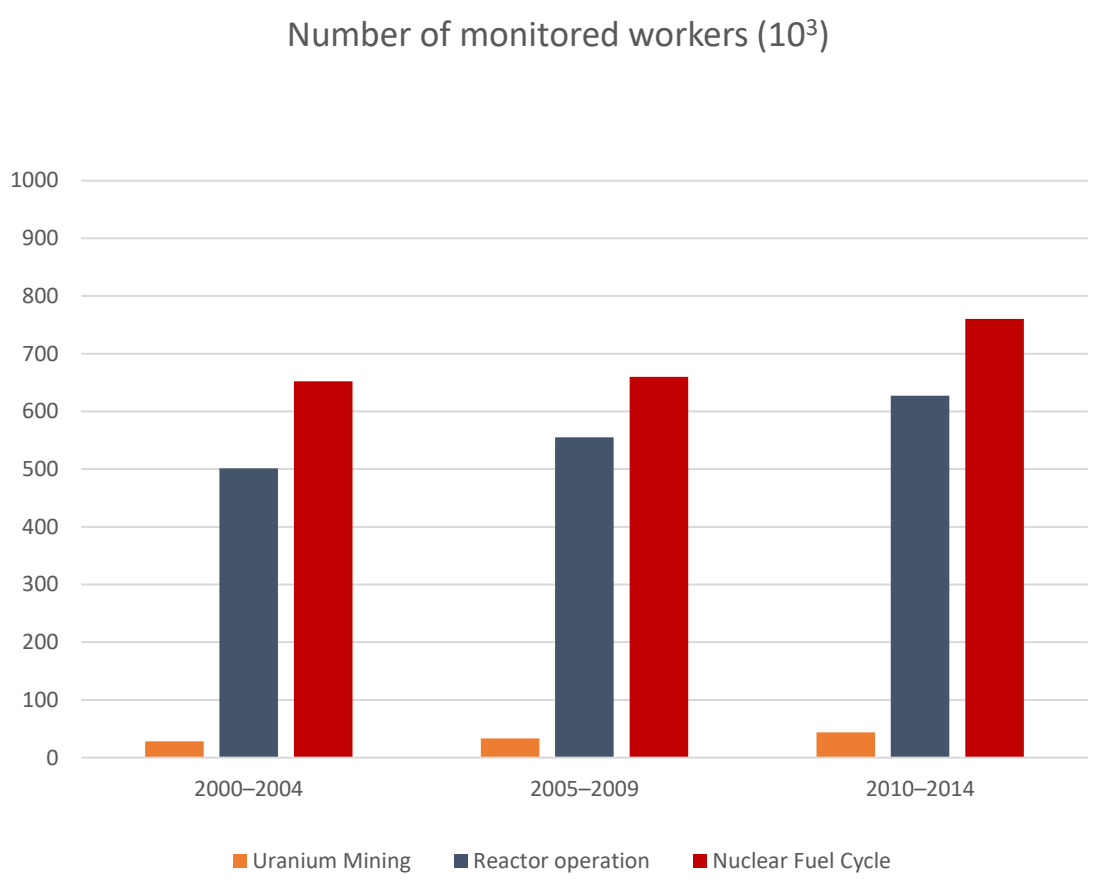
Natural Sources

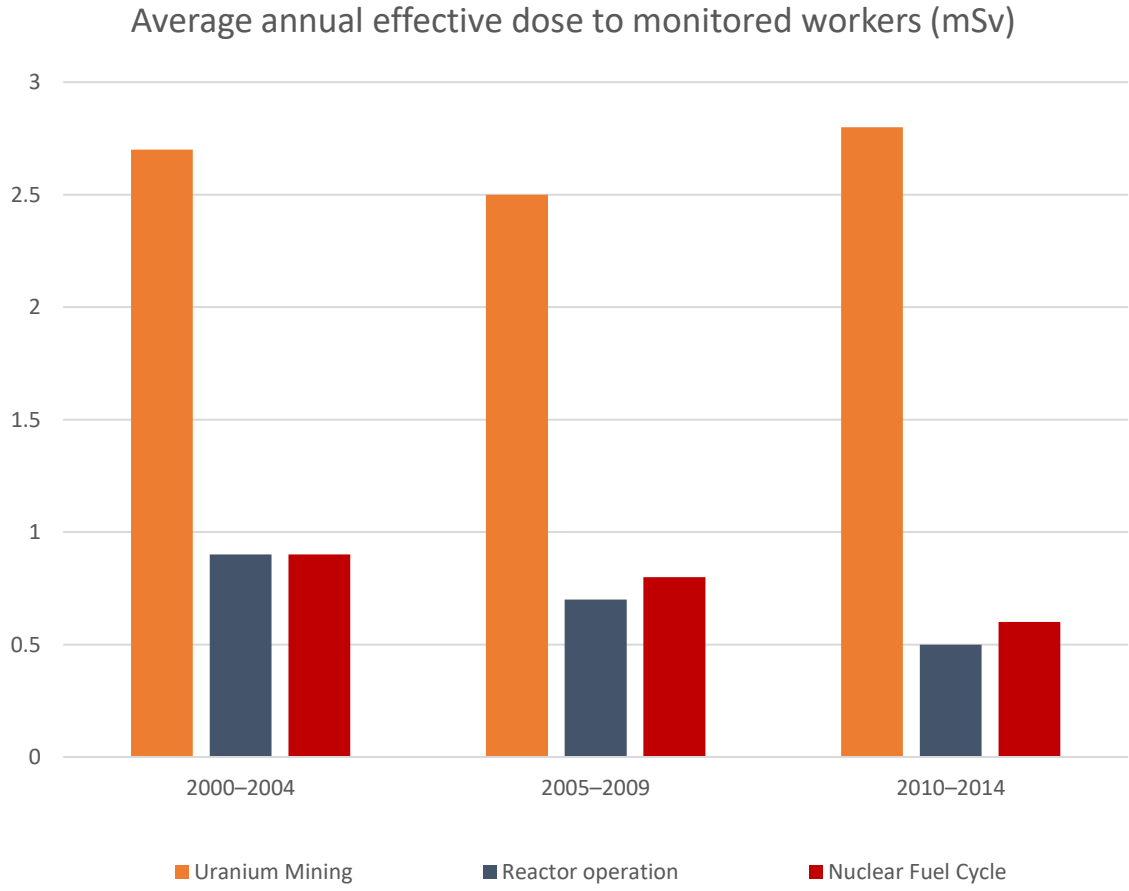
Estimates of worldwide occupational exposure from natural sources for the period 2010-2014

Sector	*Number of monitored workers (10^3)[a]*	*Annual collective effective dose (man Sv)*	*Weighted average annual effective dose (mSv)*
Civil aviation	750	2 030	2.7
Coal extraction/processing	8 000	12 800	1.6
Mineral extraction/processing	3 800	9 500	2.5
Total	**12 600**	**24 300**	**1.9**

[a] Values are rounded

Nuclear fuel cycle





Medical uses of radiation

- Include subsectors: Diagnostic radiology, Radiation therapy, Nuclear medicine, Veterinary medicine, Dental radiology
- Estimate of worldwide number of workers in the subsectors was improved, using multivariate regression modelling.
- Model not applied for average annual effective dose and collective effective dose
- Worldwide average annual effective dose derived as the average effective dose weighted by the number of workers in each country
- Weighted average annual effective dose assumed to reflect a worldwide value and used to estimate worldwide collective dose

Medical uses of radiation

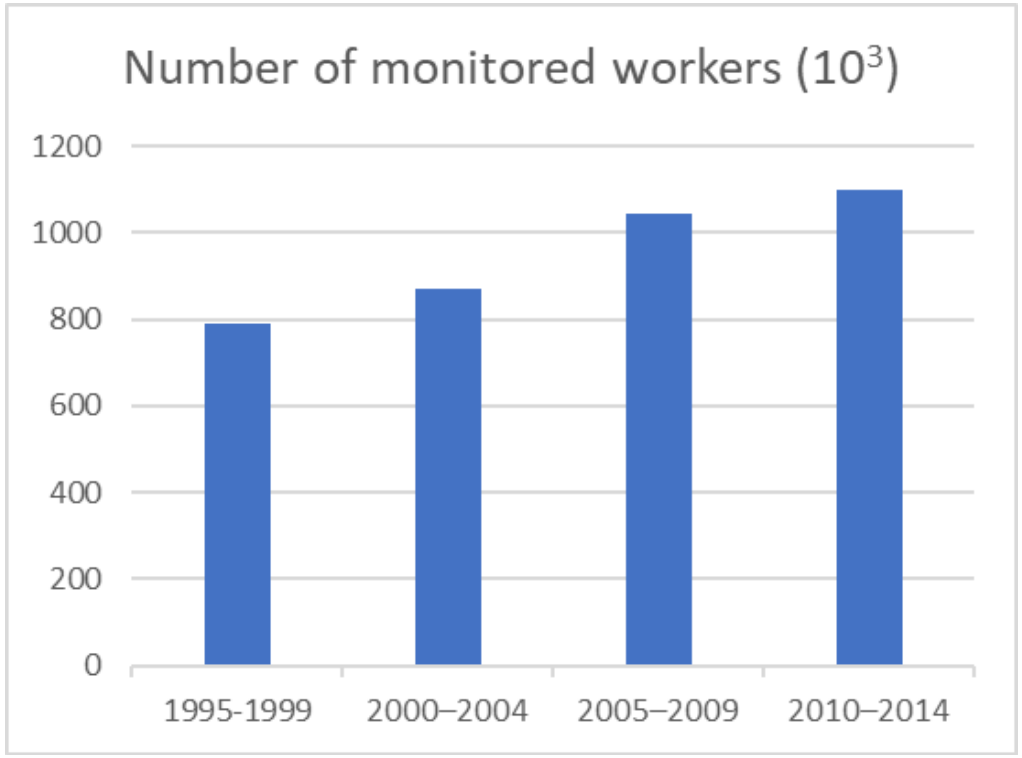
- 9 million estimated monitored workers
  - 8 million in diagnostic radiology
  - 0.2 million in nuclear medicine
  - 0.3 million in radiation therapy
- The estimated average annual effective dose is 0.5 mSv
- Annual equivalent doses to extremities is unlikely to exceed the dose limit of 500 mSv
- Derived average equivalent dose to the lens of the eye in all medical subsectors is 7 mSv
  - but should not be assumed as representative due to limited data

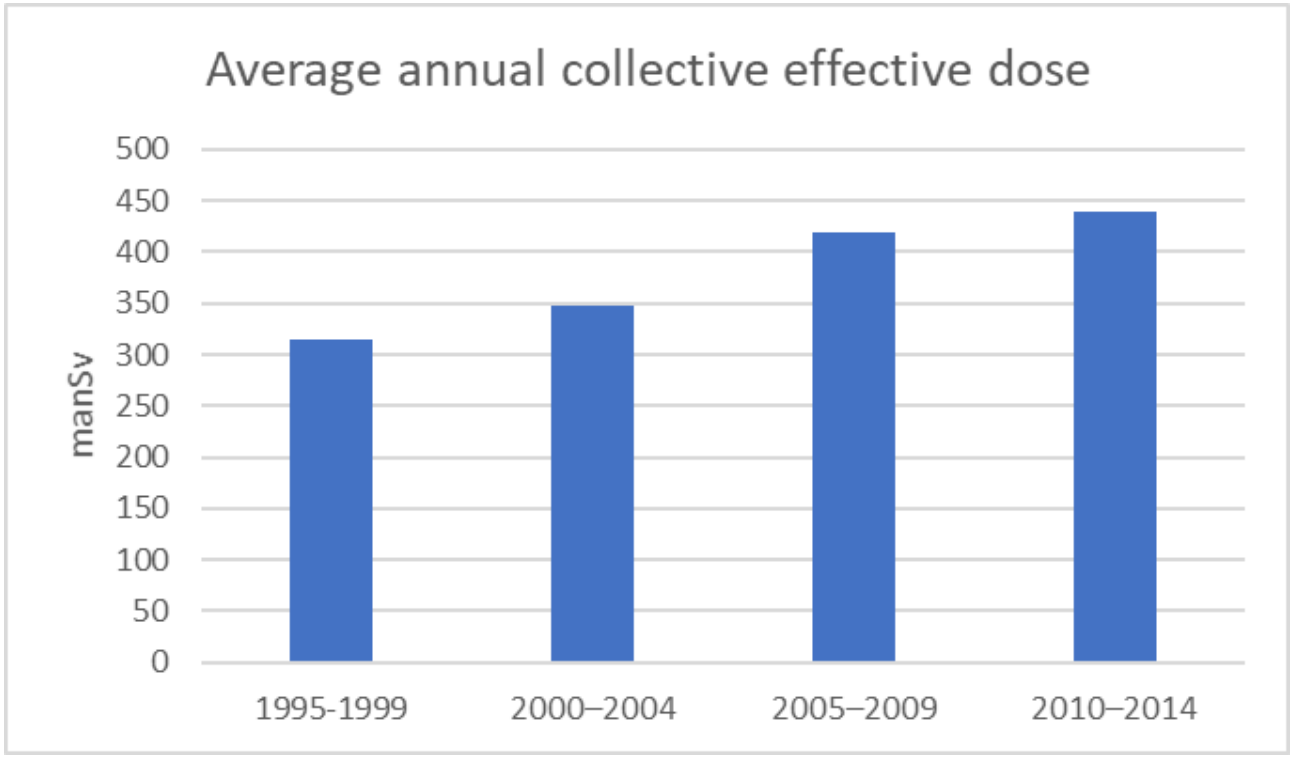
Estimated worldwide levels of occupational exposure

Period	Number of monitored workers (10^3)	Average annual collective effective dose (man Sv)	Average annual effective dose (mSv)
1980-1984	1 890	1 140	0.6
1985-1989	2 220	1 030	0.5
1990-1994	2 320	760	0.3
1995-1999	7 440	3 540	0.5
2010-2014	9 000 (5 000-17 000)	4 500	0.5 (0.26-1.0)

Industrial uses of radiation

Estimated worldwide levels of occupational exposure





Human-made Sources

- 11.4 million estimated worldwide monitored workers
- 80% working in the medical sector

Estimates of worldwide occupational exposure associated from human-made sources for the period 2010–2014

Sectors	*Number of monitored workers (10^3)[a]*	*Annual collective effective dose (man Sv)*	*Weighted average annual effective dose (mSv)*
Nuclear fuel cycle	760	485	0.6
Medical use	9 000	4 500	0.5
Industrial use	1 100	437	0.4
Miscellaneous use	540	38	0.1
Total	**11 400**	**5 460**	**0.5**

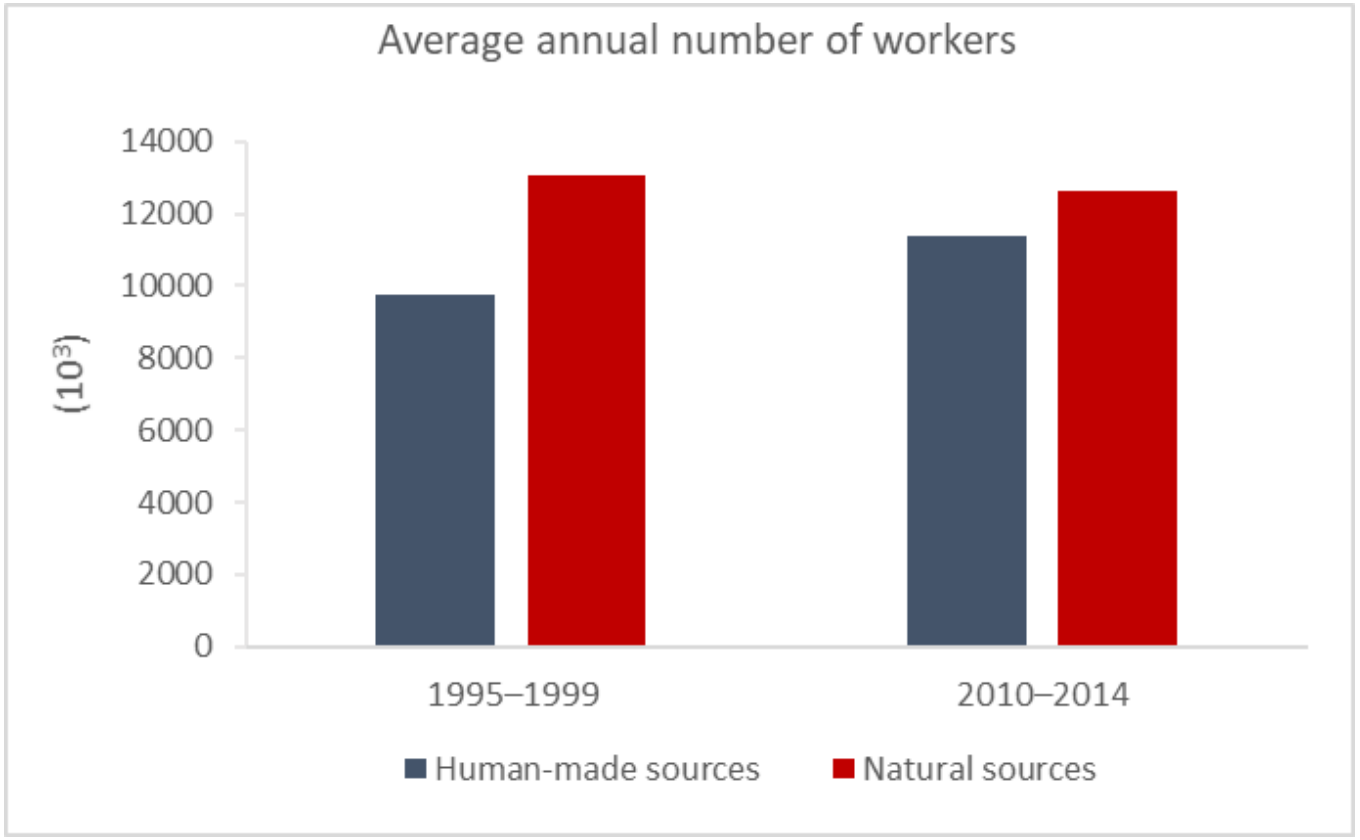
[a] Values are rounded.

Overall results for period 2010-2014

Estimated total number of workers (worldwide)

~ **24 million** annual number of workers exposed to natural and human-made sources of ionizing radiation

- 52% exposed to natural sources
- 48% exposed to human-made sources

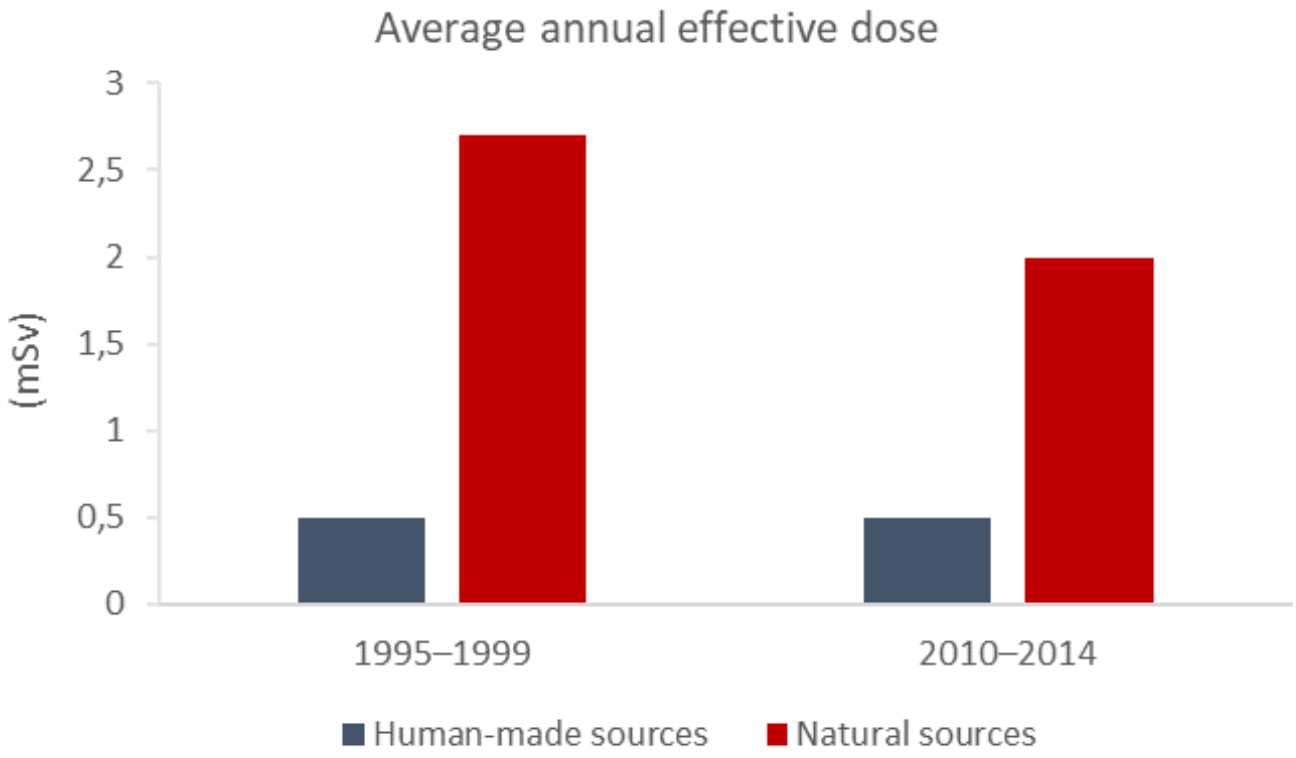


Occupational Exposure

Results for period 2010-2014

- The worldwide average annual effective dose for all workers was estimated to be around 1.2 mSv
  - about 2/3 of the estimated value for 1995-1999
- 0.5 mSv for workers exposed to human-made sources
- 2 mSv for workers exposed to natural sources

Estimated annual effective dose



Occupational Exposure Summary and Conclusions

- Overall improvement of estimates, specifically for some sectors (medical, civil aviation, NFC, etc.).
- First time uncertainties estimated (precision and accuracy)
- During the period 2010–2014, the worldwide average annual effective dose for all workers was estimated to be around 1.2 mSv (1.9 mSv for workers exposed to natural sources (excluding radon exposure in workplaces other than mines) and 0.5 mSv for workers exposed to human-made source).
- Likely underestimation of the number of workers and estimated collective effective doses, owing to the incomplete data submission for some occupational sectors for the reporting periods
- Reported data on the equivalent doses for the lens of the eye and for the hands (skin dose) were limited
- Monitoring of radon exposure of workers is not a requirement in many countries. Data on radon exposure in workplaces other than mines were very limited.

Future Evaluations

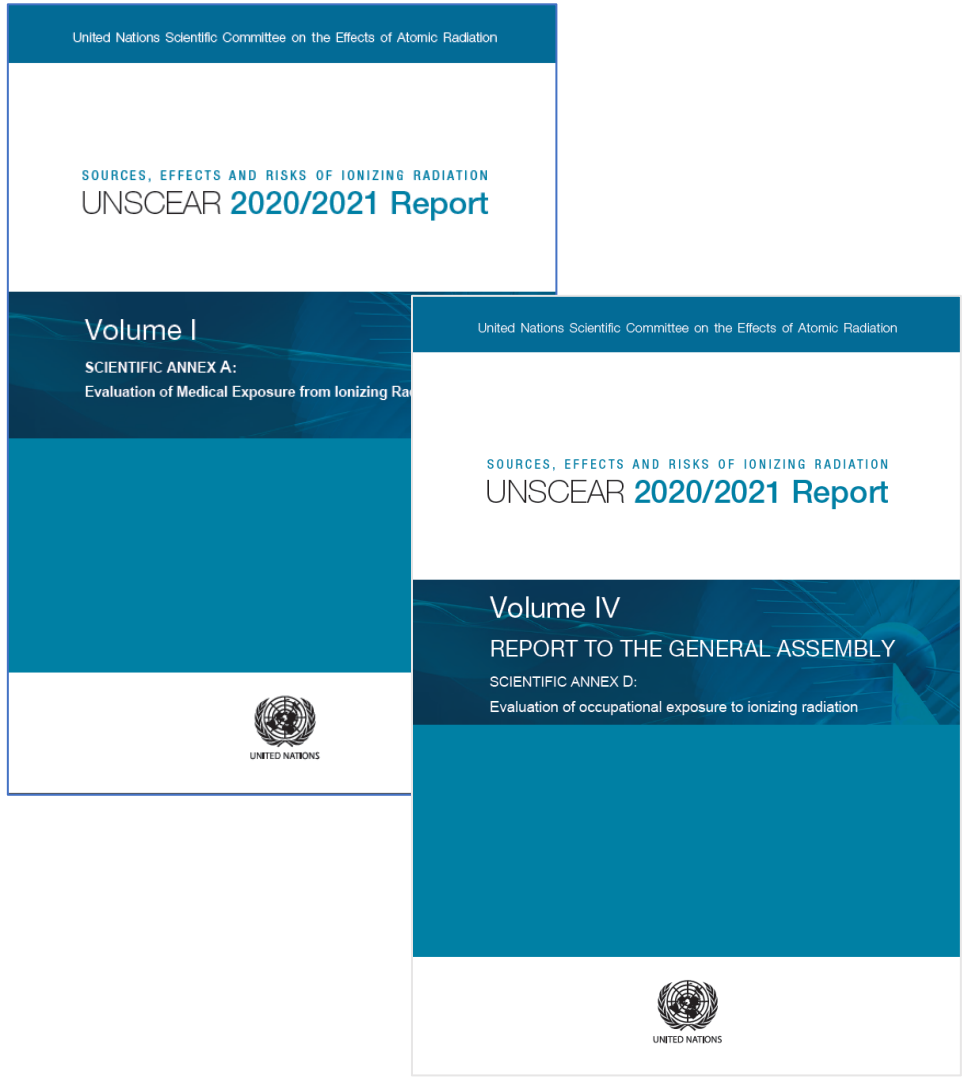
- The quality of the Committee's global evaluations of exposure levels depends on the availability of representative data and on the quality of the data collected.

  Data sources: Literature review
  UNSCEAR Global Survey on Radiation Exposure
  Data sharing with international organizations

- The Committee relies on the collection of up-to-date exposure data from all States Members of the United Nations and continues collaboration with international organizations
- According to Committee's 2022 Strategy to further improve collection, analysis and dissemination of data on radiation exposure,
  future evaluations/surveys will be relevant, useful and adapted to changing data sources and uses of radiation across the world.

Concluding Remarks

- The Committee's work is fundamental to international radiation safety. It affects decisions by governments, national and international bodies.
- The Scientific Committee has earned its respect in the international community through its objectivity, independence, competence, and quality of work.
- The Committee regularly evaluates medical, occupational and public exposure to ionizing radiation. Future UNSCEAR surveys will remain fit for purpose and adapt to changing data sources and uses of radiation across the world.
- We welcome support and appreciation from our United Nations and other partners as well as scientific experts from around the world.



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