

**NATIONAL SURVEY OF DIAGNOSTIC X-RAY EXAMINATIONS
(2000 y)**

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Abstract. The results of the recent survey on the frequency of medical and dental X-ray examinations and of radiation doses received by patients are used to assess population exposure. A total of about 10,555 million medical and dental radiological examinations have been performed in 2000 y (0.49 examination per head of population) resulting an annual per capita effective dose of 0.55 mSv. Compared with that of the last survey (1995), this is 10% lower. However, over the last ten years computed tomography (CT) increased its contribution up to 4.4% of total annual X-ray examinations and still continues; so, the population dose is underestimated without the contribution of CT doses. The much increase of CT and interventional procedures indicates an urgent need to develop activities to estimate and control these high dose procedures, in order to optimize patient and population radiological protection.

Key words: X-ray examinations, annual frequencies, effective dose, type of population dose

Rezumat. Frecvențele anuale ale diferitelor proceduri diagnostice și dozele efective per examinare sunt elementele necesare evaluării iradierii primite de populație din principala sursă artificială de expunere. Cunoașterea tendinței și structurii consumului radiologic diagnostic anual, furnizează indicații utile pentru optimizarea protecției radiologice a populației. Sunt prezentate rezultatele ultimei evaluări privind radiologia diagnostică ca frecvențe anuale ale diferitelor examinări și dozele efective rezultate. Deși consumul radiologic anual, exprimat ca număr de examene pe locuitor, are o valoare restrânsă (0,49) iar doza colectivă rezultată în 2000 (12.400 omSv) a fost cu 10% mai joasă decât cea evaluată în 1995, expunerea populației datorată radiologiei diagnostice este în prezent subestimată, prin necunoașterea contribuției tomografiei computerizate, a cărei frecvență anuală a crescut cu peste două ordine de mărime între 1990-2000. De aceea, estimarea iradierii asociate tomografiei computerizate și procedurilor intervenționale devine prioritară în cadrul programului național ce urmărește optimizarea protecției pacientului în radiodiagnosticul medical.

Cuvinte cheie: radiodiagnostic, consum radiologic anual, doză efectivă, doză colectivă

INTRODUCTION

The use of X-ray medical diagnosis was one of the beneficial applications of ionizing radiation. The range of medical X-ray diagnostic technologies has extended enormously over the past fifteen years. Computed tomography and interventional procedures are some typical exemplifications of this worldwide tendency.

The common way to assess the impact of these changes in diagnostic radiology practice on the population exposure and potential health effect is the periodical update of the annual frequency of X-ray examinations and the resulted collective dose.

In Romania the survey of diagnostic radiology begun 30 years ago (1). During 1970-1990 the updating of

X-ray procedures have been made at ten years interval. Subsequently, this period was shortened at 5 years (2). Last estimates (1995) have put the contribution from medical X-ray diagnostic practice at 90% of total artificial sources with a value of collective dose of 13,820 manSv (3). The earlier estimate was made in terms of the “effective dose equivalent”, which is based on radiation risk coefficients for a limited set of organs and tissues. Beginning with 1995 the effective dose, which provide useful information on individual doses in radiology practice and can be compared with those from natural and artificial sources have been used.

METHODOLOGY

In order to estimate the annual collective effective dose, information on the annual frequency as well as the effective dose for each type of X-ray examination are required.

We have continued the practice followed in previous reviews of diagnostic radiology surveys (2,3).

As previously, the hospitals and clinics have been considered as basic institutional units for the radiology workload in every participating district.

Figure 1 shows the geographical location of all participating hospitals included in the sample of 2000 review and their size as number of beds.

Although the large hospitals (over 1,000 beds) predominated, fact that could affect the patient dose, they have been considered most representative for diagnostic radiology pattern working in each district throughout Romania. The contribution of diagnostic workload of each region to national annual total and the weight of participating hospitals in these regions are indicated in table 1 data.

Table 1. Regional distribution of hospital sample and its contribution to national radiology workload

Region	% of regional hospitals	% of Romania diagnostic radiology workload (2000)	Population density (mill.)
North-East	19.2	11.5	3,359,684
South-East	21.0	4.8	1,148,617
South	10.0	7.9	2,074,467
South-West	10.5	5.2	1,174,956
West	12.7	8.4	2,041,129
North-West	20.0	9.0	1,692,570
Center	18.9	14.0	2,015,764
Bucharest	18.9	14.4	2,009,200

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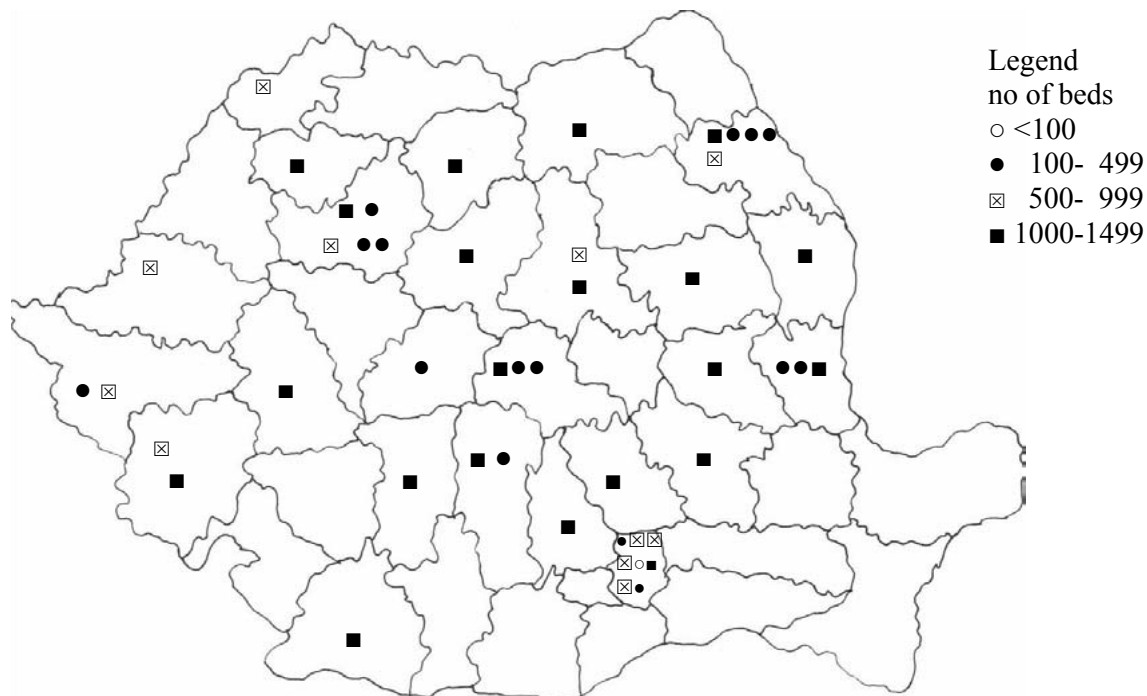


Fig. 1 Geographical location of participating hospitals

Data of a sample of 195,293 patients undergoing an X-ray examination (medical and dental) have been obtained from 46 sanitary units of different size working in 25 districts and Bucharest city. The information gathered on special records following the patient's age group and sex, both for fluoroscopic and radiographic examinations.

Information on total number of X-ray examinations performed in same year has been obtained from Ministry of Health and Family (4) and age distribution of general population from published data of National Institute of Statistics (5). The analysis used the three broad ranges of patient age UNSCEAR 2000 Report (6).

Effective doses for 18 most important types of X-ray examinations were estimated from two kinds of dosimetric quantities:

- entrance surface dose (ESD)- derived from the absorbed dose air, measured by simulation of X-ray

examinations in average conditions of use and applying the appropriate backscatter factors and,

- dose-area product (DAP) measured during X-ray examination of the patient (1540 patients undergoing mainly "complete" examinations involving fluoroscopies).

The conversion coefficients from ESD and DAP to the effective doses, used in all estimations, were those elaborated by NRPB (7).

RESULTS AND DISCUSSION

The frequency of medical X-ray examinations in Romania is similar to recent estimates for countries of health care level I such as UK, Netherlands, Sweden but less than one-half of those for Germans (fig. 2). During 2000 the overall number of X-ray diagnostic examinations (medical and dental) was 10,555 million, with an average of 490 procedures per 1,000 populations.

Compared with that of 1995 survey, this one is 20 per cent lower.

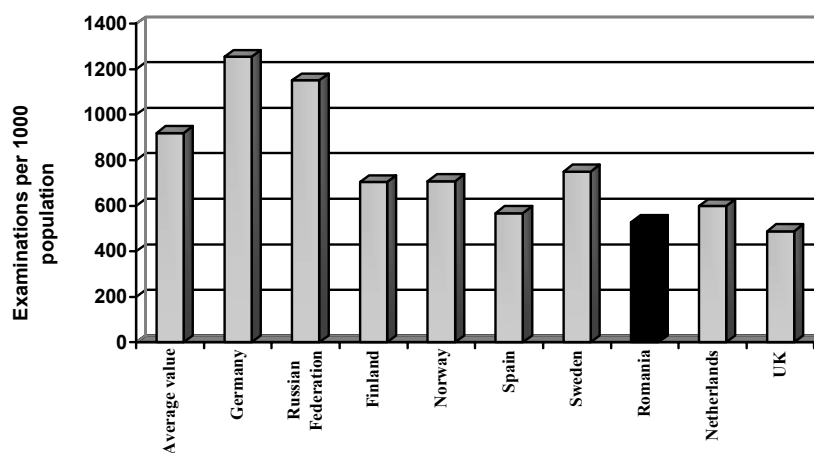


Fig. 2 The frequencies of X-ray examinations in different European countries

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Although, over a period of 11 years, the radiological consumption as number of X-ray examinations per

1,000 populations remained fairly constant, in the last years decreasing tendency can be observed (fig. 3).

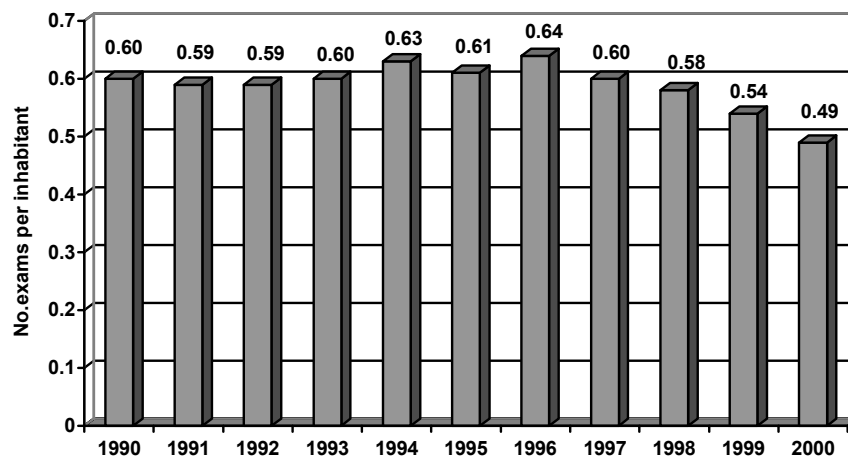


Fig. 3 Number of X-ray examinations per head of population (1990-2000)

The age distribution of patients undergoing various diagnostic X-ray examinations in 2000 and 1995 is presented in table 2.

However, the relative frequencies by different types of X-ray medical examinations performed in 2000 y indicated a change in diagnostic radiological pattern.

So, large decreases for both photo-fluorography and fluoroscopy were reported, whereas some radiographic exams doubled their contribution to annual total (hip, pelvis, head).

The most notable increase was observed for CT with over 4 percent annually contribution, a value of 400 fold higher than that of the last survey (2,4). This fact is not surprising because, data from national survey in

either countries have confirmed the increasing use of CT. So, in Germany CT accounted for an average about 3.5% of all X-ray examinations (1990-1992) and even more in Norway (1993) where CT contribution was up 7% of X-ray frequencies (6).

The increasing use of ultrasounds balanced the frequencies of some examinations as abdomen (flat) or cholecistography, which dropped to half of the 1995 value.

The examinations of chest, although with 18 per cent smaller than in 1995 (42.77 vs 60.76) are the most important type of procedure and the fluoroscopies are in top (18.0%).

The relative use of angiography and interventional procedures also increased

from 1995 survey by about 24 fold previous level.

In general, greater proportions of examinations are performed on patients over 40 y age (53.5 vs 48.5) and young people (12% vs 10%).

Older patients predominate for examinations such as angiography, cholecistography, vascular procedures, hip and gastrointestinal tract, whereas children form a greater fraction of the patients undergoing examinations of pelvis, head, chest and limb and joints.

Table 2. Annual frequencies of X-ray examinations by age

Examination type	% of totals years		Age distribution						
	2000	1995	2000 y			1995 y			
			0-15y	16-30y	>40y	0-15y	16-30y	>40y	
Chest radiography	12.06	11.06	21.60	24.00	54.00	22.33	30.58	47.09	
Chest photofluorography	12.71	26.49	3.95	55.37	40.68	2.61	57.96	39.43	
Chest fluoroscopy	18.00	23.21	7.35	34.76	57.89	10.85	37.96	51.19	
Limbs and joints	16.00	10.82	19.90	32.75	47.35	24.06	36.26	39.68	
Spine	Lumbar	4.81	2.39	5.48	31.09	63.43	4.79	33.86	61.35
	Thoracic	1.98	0.83	11.84	37.04	51.12	7.59	30.93	61.48
	Cervical	3.28	1.60	3.96	27.44	68.60	5.49	33.82	60.69
Pelvis	2.51	1.35	23.21	24.04	52.75	22.94	29.18	47.88	
Hip (one)	1.35	0.52	6.89	21.48	71.63	6.04	15.71	78.25	
Head	5.52	1.43	21.11	37.14	41.75	13.99	44.56	41.45	
Abdomen (flat)	0.65	1.77	12.48	24.61	62.91	7.61	39.38	53.01	
Upper gastrointestinal	6.87	10.08	7.51	31.76	60.73	3.93	31.09	64.98	
Lower gastrointestinal	2.32	2.45	10.12	23.64	66.24	3.91	33.03	63.06	
Cholecystography	0.18	0.31	0.36	23.21	76.43	2.05	37.75	60.20	
Urography	2.28	1.65	8.52	24.62	66.86	7.02	32.73	60.25	
Mammography-clinical dg.	0.83	0.68	5.33	39.81	54.86	0.92	43.08	56.00	
CT (non-interventional)	Head	2.16	0.01	11.98	24.82	63.20	0	20.58	79.42
	Body	2.07	-	10.80	21.00	68.20	-	-	-
Angiography	Non-cardiac	0.31	0.02	3.36	22.00	74.64	0	25.00	75.00
	Cardiac (including coronary)	0.18	-	4.01	11.11	84.88			
Interventional procedures	0.15	-	0.38	28.41	71.21				
Pelvimetry	0.08	-	13.81	19.74	66.45				
Other: Conventional chest tomography	0.56	1.27	1.81	41.04	57.78	12.88	39.90	54.22	
TOTAL of all medical examinations	100	100	11.94	34.54	53.52	10.30	41.20	48.50	
Dental	Intraoral	3.00	2.04	14.49	42.74	42.77	10.75	54.37	34.88
	Panoramic	0.14	-	28.20	34.57	37.23	-	-	-
TOTAL of all dental examinations	100	100	15.11	42.36	42.53	10.75	54.37	34.88	

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Notwithstanding specific examinations such as mammography and pelvimetry, sex distribution of diagnostic X-ray examinations did not change much in 2000 vs 1995 y: 52.4% males, 47.6% females versus 55.9% males, 44.1% females, respectively.

Data on frequency of dental X-ray examinations indicate a somewhat increase both for intraoral procedures,

the most common techniques, and panoramic radiographies. Children (0-15 y) form a substantial part of the annual total, especially for panoramic exposures (table 2).

The average values of patient effective dose (ED) per examination are presented in table 3, in comparison with those of previous survey (3).

Table 3. Effective dose from diagnostic radiology

Examination type	Effective dose (mSv)				Ratio 2000/1995	
	2000 y		1995 y			
	mean	variation	mean	variation		
Chest radiography	0.25	1.16	0.25	0.11	1.0	
Chest photofluorography	0.83	0.36	0.63	0.30	1.32	
Chest fluoroscopy	0.54	0.46	0.95	0.40	0.57	
Limbs and joints	0.04	0.03	0.08	0.03	0.50	
Spine	Lumbar	3.24	1.70	3.02	1.43	1.08
	Thoracic	1.75	0.84	2.12	1.21	0.83
	Cervical	0.31	0.20	0.21	0.13	1.48
Pelvis	2.22	1.45	2.93	1.65	0.76	
Hip (one)	0.91	0.67	1.71	0.54	0.53	
Head	0.23	0.15	0.17	0.12	1.35	
Abdomen (flat)	2.31	1.37	1.94	1.05	1.21	
Upper gastrointestinal	3.65	0.46	4.12	1.95	0.89	
Lower gastrointestinal	7.28	5.30	9.05	3.86	0.81	
Cholecystography	2.86	1.25	1.65	0.94	1.79	
Urography	7.41	4.77	5.81	2.93	1.28	
Mammography-clinical dg.	0.52	0.03	0.62	0.33	0.84	
Angiography non-carsiac	0.32	0.12	0.22	0.08	1.45	
Other: Conventional chest tomography	3.33	2.10	2.83	1.58	1.19	
TOTAL of all medical examinations	1.23	0.65	1.37	0.63	0.89	
Dental Intraoral	0.03	0.02	0.1	0.07	0.30	
TOTAL of all dental examinations	0.03	0.02	0.1	0.07	0.30	

Eight out of twenty (40%) conventional examinations are performed with higher effective dose (the 2000/1995 ratio

ranged from 1.19 to 1.79) indicating either old technologies/old equipment

or poor concern for patient protection during examination.

Meantime, some examinations halved their effective dose, the most influential being the chest fluoroscopy, probably as an effect of compulsory use of image intensifiers.

The effective dose of an average patient from all annual medical examinations

of 1.23 mSv is about 90% of 1995 value (1.37 mSv).

Trends in diagnostic radiology

Trends in the global use of diagnostic X-rays are highlighted in figure 4 which illustrates a constant increase for CT use in the last five years and a decreasing one (more slowly) of conventional procedures.

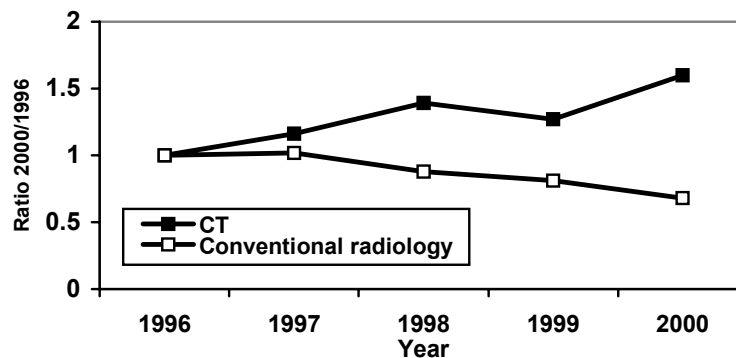


Fig. 4 Trends in CT use in comparison with conventional examinations

The imaging modality of CT has proliferated steadily to form an integral part of medical radiology. Unfortunately, the growth of the technique is not accompanied by patient dosimetry, although, many surveys confirmed the high doses involved (6).

Taking into account the last annual frequencies of these examinations (4.3% annual total), the collective dose of 12,420 manSv (conventional procedures), although 10% lesser than that 1995, is underestimated (3).

If in 1995 the computed tomography, as well as the other examinations, have had small annual frequencies, during the last five years its frequencies increased

significantly; so, its contribution adds a significant amount to population dose.

Supposing that the CT mean effective doses are similar with those indicated in UNSCEAR 2000 Report of 2.3 mSv (CT head) and 13.3 mSv (CT body) as typical values for countries with level I health care (5), then the present annual population dose would be 27% higher if we take into account CT frequencies of 4.4% of total annual examinations.

Even speculative that estimation is, it indicates to health authorities that the patient dose in computed tomography, as well as interventional procedures, must become a priority of the national radiological protection program.

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CONCLUSIONS

1. The total annual X-ray diagnostic examinations were 10,899 million with an average of 490 procedures per 1,000 population.
2. Some differences in patient age distribution are apparent from previous survey, older patients and children undergoing more examinations.
3. The pattern of diagnostic radiology changed between 1995 and 2000, by a slowly decrease of conventional X-ray examinations and an incessant rise of computed tomography, angiography and interventional procedures.
4. Average patient effective dose from all medical examinations is 1.23 mSv, about 90% of previously estimation (1.37 mSv).
5. Annual collective dose from diagnostic conventional X-ray is about 12,420 manSV, a value underestimated by the unknown contribution of computed tomography and interventional procedures.

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