

## HOW OFTEN ARE X-RAYS USED AS DIAGNOSTIC TOOL BY HEALTHCARE PROVIDERS IN THE MAZOVIAN PROVINCE OF POLAND

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### ABSTRACT

**Background.** Within the medical facilities provided by state healthcare services, a universally applied technique for patient diagnosis and treatment relies on ionising radiation; for example in radiotherapy and X-ray (ie. examination). Human exposure to such radiation is not however entirely free of associated health risks.

**Objectives.** To determine and estimate the numbers and types of X-ray based medical procedures that are performed in general and dental radiography, mammography and computer tomography on patients from the Mazovian province in Poland, which included children, women and men subjects.

**Material and Methods.** The numbers of patient subjects undergoing X-rays was estimated by surveying the patient intake in X-ray testing rooms within the healthcare facilities of the Mazovian province. Questionnaires were either dispatched by mail to such healthcare centres or were completed by the X-ray operating staff during the testing of quality control. Results so obtained from the latter, were compared to entries from the X-ray rooms' register

**Results.** During 2009, the number of X-rays performed were 7612046 equivalent to 1460 examinations per 1000 inhabitants. The majority were done on women ie. 3847961 (50.55%), followed by 3193781 (41.96%) on men and 570 304 (7.49%) for children.

**Conclusions.** Results indicated that the predominating medical procedure used of this type, was for making general diagnoses; especially through using chest radiography. Others included, in descending order; dental X-ray (mainly intra-oral examination), computer tomography (mainly CT head examinations) and mammography procedures. It was also found that the annual numbers of having X-rays has increased compared to previous years.

**Key words:** *X-ray medical diagnostic procedures, number and types of X-ray examinations*

### STRESZCZENIE

**Wprowadzenie.** W placówkach służby zdrowia powszechnie wykorzystywane jest promieniowanie jonizujące w celach medycznych zarówno w diagnostyce jak i terapii. Promieniowanie to nie jest jednak całkowicie obojętne dla zdrowia.

**Cel.** Celem niniejszych badań było określenie i ocena liczby i rodzaju wykonywanych na terenie województwa mazowieckiego procedur medycznych z zakresu diagnostyki ogólnej, stomatologii, mammografii i tomografii komputerowej, osobno dla dzieci, kobiet i mężczyzn.

**Material i metody.** Szacowanie liczby badań rentgenowskich przeprowadzono metodę ankietową. Zbierano dane liczbowe z placówek służby zdrowia przy wykorzystaniu opracowanej w tym celu ankiety. Ankiety przekazywano listownie do wylosowanych placówek służby zdrowia na terenie województwa mazowieckiego lub proszono o ich wypełnienie w trakcie przeprowadzania specjalistycznych testów parametrów fizycznych medycznych aparatów rentgenowskich. W tym drugim przypadku weryfikowano jednocześnie zgodność danych w wypełnianych ankietach w stosunku do zapisów w prowadzonych rejestrach badań pacjentów w pracowniach rentgenowskiej.

**Wyniki.** Oszacowano, iż w 2009 roku na obszarze objętym niniejszymi badaniami wykonano łącznie 7612046 diagnostycznych badań rentgenowskich, co daje 1460 badań na 1000 mieszkańców. Najwięcej badań przeprowadzono u kobiet 3847961 (50.55 %), w dalszej kolejności u mężczyzn 3193781 (41.96 %) i dzieci 570304 (7.49 %).

**Wnioski.** W wyniku przeprowadzonych analiz stwierdzono, iż największy udział w strukturze wykonywanych badań rtg miały procedury medyczne z zakresu diagnostyki ogólnej, w tym przede wszystkim badania klatki piersiowej. Na drugim miejscu znajdują się badania rentgenowskie stomatologiczne, głównie wewnątrzustne (punktowe). W dalszej kolejności pod względem liczby wykonywanych badań rtg uplasowały się procedury medyczne z zakresu tomografii komputerowej,

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wśród których dominowały badania tomograficzne CT głowy oraz procedury medyczne związane z badaniami mammograficznymi. Zaobserwowano wzrost liczby wykonywanych rentgenowskich procedur medycznych w odniesieniu do danych z wcześniej prowadzonych tego typu badań na terenie Polski.

**Słowa kluczowe:** *rentgenowskie procedury medyczne, liczba i rodzaje badań*

## INTRODUCTION

Since time immemorial, mankind has always been exposed to ionising radiation from natural sources. However since the discovery of radioactivity by Becquerel and subsequently X-rays by *Rontgen* [8], humans have also been exposed to ionising radiation from artificial sources. For the study purposes, it is assumed that exposure to ionising radiation from such artificial sources constitutes 26.2% of the total radiation exposure for the average Polish person, of which the majority originates from medical/healthcare interventions.

Making a medical diagnosis often requires examining a patient using X-ray techniques which is not without its attendant health risks. It is thus important to know how many X-rays were done on a population per given period, in order to estimate the received dose of radiation. Based on such considerations, the cancer risk can be evaluated resulting from radiation exposure to artificial sources using IRCP and BEIR models [1, 6]. In Poland such radiation exposure data has only been available for the last 10-12 years [7, 13]. Hitherto, not only has the construction of X-ray units changed, but also X-rays have become more popular and more easily available. Moreover, the advent of new technologies has changed the types now used eg. X-ray computer tomography. As a result, nowadays it is important that the number of X-ray examinations undergone should be monitored for any given population. The presented study provides estimates on the number of X-rays undertaken in the Polish province of Mazovia.

## MATERIAL AND METHODS

The primary tool of the survey was a questionnaire, designed and separately tailored for children, women or men living in the Mazovian region of Poland. This included a main question put to all subjects, on the number of X-rays undergone for the following purposes; general diagnoses, dental radiographs, mammography or computer tomography. Each of these diagnostic procedures were then sub-divided into more detailed questions as now described. For making general diagnoses, questions on the following X-rayed areas were posed; head, spine (cervical, thoracic, and lumbo - sacral regions), chest, abdomen, pelvis, urinary tract, limbs, (hands, elbows, shoulders, femurs, knees and feet). Questions on dental radiographs concerned the

intraoral, panoramic or cephalometric areas. For computer tomography, these regarded examinations of head, chest, abdomen, pelvis or lower limbs. Mammography was also included in the questionnaire as well as questions on other X-ray examinations not mentioned as above.

For the survey, medical centres providing health-care were selected at random and which then received the same number of questionnaires, irrespective of the types of X-ray performed. Questionnaires were sent by mail to 30% of all medical units within the Mazovian region that had X-ray rooms intended for performing general diagnoses, dental radiographs, mammography or computer tomography. They were also completed by X-ray operators during quality control testing. The X-ray operators were asked to give the number of X-rays performed, per single X-ray unit, over the month of May in 2009 for all the aforementioned types of examinations. The reason for deliberately choosing May, was that it is considered to be the most representative month of the year, as had been previously established with the X-ray specialists from Mazovia.

The average number of X-rays done per examination type were thus estimated as well as the total number of X-rays performed in the entire Mazovian region (taking into account the numbers of X-ray units and of X-rays done per single unit). Non-residents of Mazovia were not included, which made up around 2% of the total X-rays performed. From this data, the number of X-rays per 1000 people living in Mazovia were estimated for the most important X-ray medical procedures based on patient's gender and age [9].

## RESULTS AND DISCUSSION

Out of the 530 questionnaires sent, replies/feedback were received from 204 (38.49%). The data thus demonstrated that 7207413 X-rays had been performed during 2009. This works out as 1460 X-rays per 1000 persons, given that the population of the Mazovian province is 5207413 [10]. X-ray data for particular types of examinations and their percentage share are presented in Figures 1 and 2. Tables 1, 2 and 3 show data for the number of X-ray examinations per 1000 citizens divided according to patient group; children, women and men.

Figure 1 demonstrates that the majority of X-rays performed were for general diagnostic examinations; 5596057 (73.52%), including Chest AP and LAT (shown in

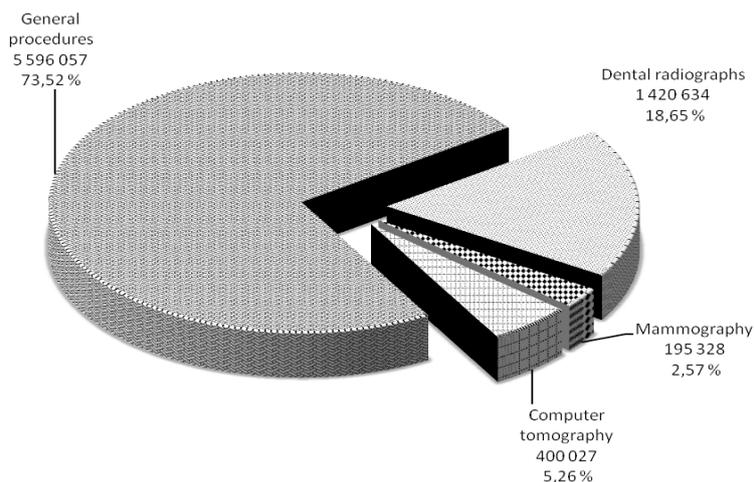


Figure 1. The number of X-rays performed in the Mazovian province of Poland according to examination type

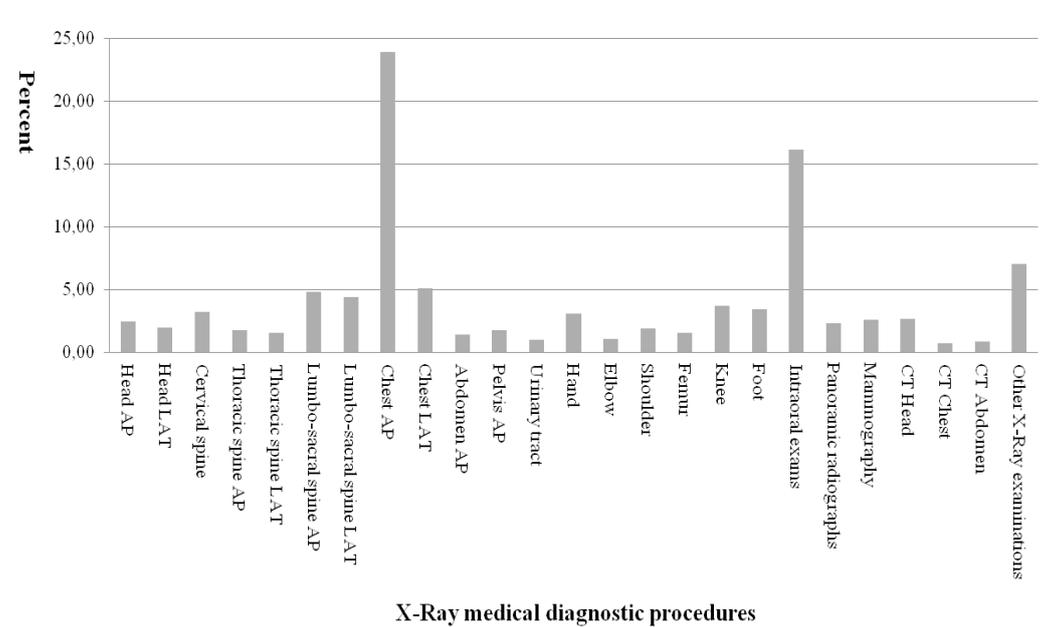


Figure 2. The percentage share of various X-ray procedures for diagnostic examination

Figure 2); 2202747 (28.94%). Data for dental radiographs (Figure 1) showed that 1420634 (18.65%) X-rays had been done, especially the intraoral ones 1228610 (86.48%), as presented in Table 2. There were 400027 (5.26%) X-rays performed in computer tomography (CT) are presented in Figure 1, where the most popular were head examinations, as shown in Table 3; 199920 (49.98%). Numbers of X-rays taken for mammography (Figure 1) were 195328 (2.57%). It should of course be noted that none of the X-ray rooms reported conducting mammography on men. Data from Table 1 indicate that women are X-rayed more frequently than men, especially for spinal examinations; 687971 (57.50%) and Chest AP and LAT; 1087862 (49.39%). In comparison, there were 1003322 (45.55%) chest X-rays done on men. It was also found that women had more X-rays of limbs than men, respectively; 491087 (44.05%) and 451643 (40.50%), whereas for children the numbers were 172304 (15.45%). Likewise, many more women

than men, had dental radiographs performed, respectively; 722621 (50.87%) and 568128 (39.99%), with children at 129885 (9.14%). It was only in computer tomography (Table 3) that the number of X-rays were higher for men than women and children, respectively; 200060 (50.03%), 182188 (45.57%) and 17594 (4.40%).

It is also worthwhile noting the X-ray results from previous years in the Mazovian province so that progressing changes can be observed; with the qualification that data from one district were missing. The last analysis had been performed in 2004, which covered all provinces of Poland and demonstrated 830 X-rays per 1000 persons [12]. Some of these included using now obsolete procedures such as photofluorography, which has subsequently been shown to bear a significant radiation risk to the patient. Although the current study represents the largest province of Poland, the authors have made extrapolations to the rest of the country,

Table 1. The sub-divisional structure of the general diagnoses procedures with corresponding incidences of performed X-rays observed in the Mazovian province (for 2009).

Type of X-ray examination	X-ray medical procedure	Groups of patients	Number of X-ray examinations in 2009	Number of X-rays performed per 1000 in a group of patients	Number of X-rays performed per 1000 citizens	Total number of X-ray examinations
General diagnostic	Head AP	Children	22 499	25	36	185 815
		Women	75 367	33		
		Men	87 949	43		
	Head LAT	Children	13 202	14	29	149 867
		Women	60 864	27		
		Men	75 801	37		
	Cervical spine	Children	6 260	7	47	243 951
		Women	146 457	64		
		Men	91 234	45		
	Thoracic spine AP/PA	Children	10 722	12	26	134 867
		Women	72 764	32		
		Men	51 381	25		
	Thoracic spine LAT	Children	3 099	3	23	118 257
		Women	66 938	29		
		Men	48 220	24		
	Lumbo-sacral spine AP	Children	11 156	12	70	367 165
		Women	210 172	92		
		Men	145 837	72		
	Lumbi-sacral spine LAT	Children	5 764	6	64	332 147
		Women	191 640	84		
		Men	134 743	66		
	Chest AP	Children	107 534	118	348	1 817 545
		Women	881 595	387		
		Men	828 416	408		
	Chest LAT	Children	4 029	4	74	385 202
		Women	206 267	90		
		Men	174 906	86		
	Abdomen AP	Children	5 268	6	20	105 117
		Women	45 493	20		
		Men	54 356	27		
	Pelvis AP	Children	9 297	10	25	130 777
		Women	75 677	33		
		Men	45 803	23		
	Urinary tract	Children	682	1	5	25 907
		Women	10 660	5		
		Men	14 565	7		
Urinary tract with contrast	Children	2 975	3	9	46 608	
	Women	17 540	8			
	Men	26 093	13			
Hand	Children	49 955	55	45	233 290	
	Women	87 825	39			
	Men	95 510	47			
Elbow	Children	15 743	17	15	79 272	
	Women	30 618	13			
	Men	32 911	16			
Shoulder	Children	34 151	37	28	144 412	
	Women	54 356	24			
	Men	55 905	28			
Femur	Children	15 929	17	22	116 398	
	Women	45 245	20			
	Men	55 224	27			
Knee	Children	18 966	21	54	279 775	
	Women	152 903	67			
	Men	107 906	53			
Foot	Children	37 560	41	50	261 988	
	Women	120 240	53			
	Men	104 187	51			
Other X-ray examinations	Children	48 034	53	84	437 699	
	Women	195 111	86			
	Men	194 553	96			
Total number of X-ray examinations: 5 596 057				Number of citizens: 5 222 167 • Children (0-16 years old) 911 364 • Women 2 280 436 • Men 2 030 367		

Table 2. The sub-divisional structure of the X-ray dental and mammography procedures with corresponding incidences of performed X-rays observed in the Mazovian province (for 2009).

Type of X-ray examination	X-ray medical procedures	Groups of patients	Number of X-ray examinations in 2009	Number of X-rays performed per 1000 patients	Number of X-rays performed per 1000 citizens
Dental radiographs	Intraoral	Children	88 845	140	234
		Women	639 137	280	
		Men	500 628	247	
	Panoramic	Children	34 020	72	34
		Women	78 624	34	
		Men	63 720	31	
	Cephalometric	Children	7 020	15	3
		Women	4 860	2	
		Men	3 780	2	
Total number of X-ray examinations:		1 420 634	Number of citizens:		5 222 167
• Intraoral:		1 228 610	• Children (5-16 years old)		632 960 (Intraoral)
• Panoramic:		176 364	• Children (7-16 years old)		535 944 (Panoramic)
• Cephalometric:		15 660	• Women		2 280 436
			• Men		2 030 367
Mammography	Women		195 328	285	37
Total number of X-ray examinations:		195 328	Women aged 50-69 years: 685 927		

Table 3. The sub-divisional structure of the computer tomography procedures with corresponding incidences of performed X-rays observed in the Mazovian province (for 2009).

Type of X-ray examination	X-ray medical procedures	Groups of patients	Number of X-ray examinations in 2009	Number of X-rays performed per 1000 patients	Number of X-rays performed per 1000 citizens
Computer tomography	CT Head	Children	13 627	22	38
		Women	91 047	40	
		Men	95 247	47	
	CT Chest	Children	1 260	2	10
		Women	22 167	10	
		Men	28 653	14	
	CT Abdomen	Children	327	1	13
		Women	30 100	13	
		Men	35 840	18	
	CT Pelvis	Children	93	-	2
		Women	6 580	3	
		Men	4 993	2	
	CT lower limb	Children	187	-	1
		Women	1 587	1	
		Men	1 447	1	
Other CT examinations	Children	2 100	3	13	
	Women	30 799	13		
	Men	33 973	17		
Total number of CT examinations:		400 027	Number of citizens:		5 222 167
• CT Head:		199 921	• Children (5-16 years old)		571 299
• CT Chest:		52 080	• Women		2 310 692
• CT Abdomen:		66 267	• Men		2 061 772
• CT Pelvis:		11 666			
• CT lower limb:		3 221			
• Other CT examinations:		66 872			

with the proviso that the incidence of X-raying made per 1000 persons are not necessarily replicated in other areas/provinces. Reasons for this being so, are the non-uniform availability of X-ray rooms and differing numbers of X-ray units; the former being an important factor for computer tomography and mammography [2]. In 2009 it was estimated that 1150 X-rays were performed per 1000 person in total, which when compared to previously recent years, shows an increase. During 1991 – 1996, there were 641 X-rays done per 1000 persons [14] rising to 830 X-rays per 1000 persons [12]. These Polish results are generally comparable to rates found

in other European countries, however these may sometimes be unreliable as such data is not always regularly published and might be only available for certain past years. A French study indicated that in 2002 there were from 977 up to 1179 X-rays done per 1000 citizens [11] with a tendency to increase [14]. In 2008, from the UK there were 752 X-rays performed per 1000 citizens [5] which represented a 54% increase from previous years 1991-1996. Germany demonstrated rates of 1254 X-rays per 1000 citizens in years 1991-1996 [14].

As emphasised in the introduction, it is vital to regularly monitor the number of X-ray treatments as it

constitutes a starting point for estimating cancer risk in any given population resulting from exposure to ionizing radiation. To achieve this, the best method is by surveying Healthcare Service Providers via a questionnaire. Data so received, may not however be completely accurate due to the following reasons; results from one month extrapolated to a whole year, the percentage of received answers and how correctly were questionnaires completed - it being possible to verify the latter by a scheduled quality test control. The questionnaire data were also compared to entries from the X-ray rooms' register, per given patient, and no major discrepancies were reported. It was also necessary to randomise the choice of medical centres providing health care so as to assure the diversity of the received data (both from central hospitals as well as from single X-ray rooms with only one X-ray unit available). The total uncertainty of the obtained results should not be higher than 14% [12]. It also worth mentioning that X-ray examinations in the Mazovian district were done by 1067 X-ray unit operators [9], in dental radiography by 6586 dentists, whilst 363 radiologists issued reports on results from X-ray films and radiography [3].

## CONCLUSIONS

1. In 2009, there were 7612046 X-rays performed in the Mazovian district, equivalent to 1460 X-rays per 1000 persons.
2. Results indicate that the dominating medical procedure was for general diagnoses (73.52%), followed by dental radiography (18.65%), computer tomography (5.26%) and mammography (2.57%).
3. The most popular X-ray diagnostic procedure in the Mazovian district were chest radiography examinations 2207747 (28.94 %) and spinal radiography 1196387 (15.72 %).
4. The majority of X-rays were done on women 3847961 (50.55 %) compared to men 3193781 (41.96 %) and children 570304 (7.49%).

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## REFERENCES

1. BEIR VII Phase 2: Health risk from exposure to low levels of ionizing radiation. National Academy Press, 2006.
2. Bekas M., Pachocki K. A., Różycki Z., Wieprzowski K., Fabiszewska E.: Evaluation of mammographic units in Poland in the view of current requirements of radiation protection regulations. *Rocz Panstw Zakl Hig* 2006;57(1):81-90 (in Polish).
3. Statistical Bulletin of the Ministry of Health, Warsaw, 2010 (in Polish).
4. Activities of the president of the National Atomic Energy Agency and assessment of nuclear safety and radiation protection in Poland in 2011. Państwowa Agencja Atomistyki, Warszawa, 2012 (in Polish).
5. Hart D., Wall B.F., Hillier M.C., Shrimpton P.C.: Frequency and Collective Dose for Medical and Dental X-ray Examination in the UK, 2008. Report HPA-CRCE-012, HPA, 2010.
6. ICRP Publication 103: The 2007 Recommendations of the International Commission on Radiological, *Annals of the ICRP* 37 (2-7), 2007.
7. Jankowski J.: Assessment of risk of cancer in Polish population as a result of the use of X-ray in medicine. Papers on the degree of habilitated doctor. Instytut Medycyny Pracy, Łódź 1980 (in Polish).
8. Leszczyński S.: History of Polish radiology in relation to world radiology. *Medycyna Praktyczna*, Kraków 2000 (in Polish).
9. Mazovian Provincial Office, Department of Social Policy, Medical Statistic Branch. Evaluation of the health status of Mazovian province population. Warsaw, 2010 (in Polish).
10. Demographic Yearbook. Central Statistical Office, Warsaw, 2010 (in Polish).
11. Scnaff P., Donadieu J., Pirard P., Aubert B.: Population exposure to ionizing radiation from medical examination in France. *Br J Radiol* 2008;81:204-213.
12. Staniszewska M. A., Papierz S.: Diagnostic X-ray examinations in Poland in 2004 in view of the population exposure: the structure and trends. *Med Prac* 2006;57(3):251-256 (in Polish).
13. Staniszewska M.A.: X-ray diagnostic as risk factor for Polish population in 1986 and 1995. Papers on the degree of habilitated doctor. Instytut Medycyny Pracy, Łódź, 2000 (in Polish).
14. United Nations Scientific Committee on the Effects of Atomic Radiation, Sources and effects of ionizing radiation. United Nations, New York, 2000.

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