Exposure of the Population of Ngaoundere-Cameroon to Ionizing Radiation Related to Medical Diagnosis in 2018

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Abstract

Background: Medical applications are the main source of exposure to ionizing radiation of human origin. Our objective was to determine the data on exposure to ionizing radiation of medical origin of the population of Ngaoundéré in 2018.Methodology: It was a cross-sectional descriptive study conducted within a period of one year, in the different hospitals of Ngaoundéré, with a functional medical imaging service. The variables studied were age, sex, type of examination, anatomical region and effective dose. The statistical analysis was performed using the Microsoft Office 2016 software, Sphinx V5; the effective dosage was calculated using the Internet Dose calculation Module.

Index terms— exposure, ionizing radiation, conventional radiology, city of ngaoundéré, 2018

1 Introduction

edical applications are by far the largest source of exposure to ionizing radiation of human origin. Thus, diagnostic procedures account for more than 97% of artificial exposure and nearly 26% of total exposure of the population [1]. This exposure leads to absorption by the subject in contact with a dose likely to induce harmful biological effects on the body which are of two types, the so-called deterministic short-term effects directly related to cellular lesions for which a threshold of appearance has been defined and the so-called stochastic long-term or random effects dominated by cancers and genetic anomalies and which can develop from few hours to several years [1]. It would therefore be important to regularly estimate this medical exposure and analyze its evolution over time. A recent publication on the exposure of the population to ionizing radiation in the United States points out that medical exposure per year and per individual has increased six-fold, since the 1980s **??**2]. Directive 97/43/ Euratom [3] states in Article 12 on the estimation of doses received by the public: "Member States shall ensure that the distribution of individual doses generated by exposures for medical purposes is determined for the population and for the reference groups concerning it, depending on whether the Member States deems it necessary". The current revision of Directive 96/29/ Euratom [4] on basic radiation protection standards should introduce an additional requirement: "Member States shall ensure that the distribution of individual doses due to medical exposure is determined and takes into account the age and sex distribution of the exposed population". In recent years, many actions, both at European and American level, have been initiated in order to harmonize methods of collecting information and thus to have reliable indicators on the medical exposure of the population. This is the case of the European Union's Dose Datamed project **??**2005) **??**2006) **??**2007) which led to the publication of the report "radiation protection no. 154: European guidance on estimating population doses from medical x-ray procedures (2008)" [5] and the "International action plan for the radiological protection of patients" action plan led by the International Atomic Energy Agency (IAEA). Great Britain is undoubtedly the country that has done the most in this field because, in the late eighties, the National Radiological Protection Board (NRPB) set up a national system of dose evaluation. By type of examination based on measurement campaigns conducted by a sentinel network of hospital services. Other countries, such as the Netherlands, Switzerland or Norway, also rely on annual activity data from all or some hospitals. For several years now, the fleet of heavy imaging equipments has expanded in Cameroon, with the creation of multiple imaging centers for public and private purposes therefore, an increase in examinations and protocols, with the result of irradiation of the population. However, the global exposure of the population to ionizing radiation of medical origin has never been evaluated in our country in

general and in Ngaoundere in particular despite the creation of the National Radiation Protection Agency in 2002 with the primary mission of protecting people, goods and the environment against ionizing radiation [6].

It is also responsible for the dosimetry of patients, professionals, the public, the environment in the imaging services. This is why it is necessary to set up a long-term system to monitor practices both from the point of view of the knowledge of the nature, the frequency and the distribution of examinations in the population, then from the point of view of doses given to patients during these examinations. Thus, we proposed to conduct this pilot study to evaluate the medical exposure of the population of Ngaoundéré to ionizing radiation of medical origin in 2018, which could be the start point for monitoring these populations.

2 II.

3 Methodology

The study was carried out in the two Hospitals with medical imaging departments equipped with ionizing radiation equipment in the city of Ngaoundéré, namely the medical imaging department of the Regional Hospital and the Patient Clinic. This was a descriptive cross-sectional study, conducted within a period of one year, from January to December 2018, including all patients coming to perform a medical imaging examination, using ionizing radiation. The diagnostic acts selected for the study were those of conventional radiology, which are the only ones currently performed in the city of Ngaoundere and grouped according to the anatomical zone explored. Finally, 25 areas were defined for this study. The variables studied were the frequencies of diagnostic procedures by anatomical region, age, sex, examination required, anatomical region, indication of examination, irradiation parameters and irradiation dose. The collection took place as practices in the imaging centers over a period of one year. The extrapolation of the results of the survey sample to the general population was based on data from the last census of the general population of Cameroon; which estimated the population of Ngaoundere at about 200,000 inhabitants. The study will therefore make it possible to estimate the population actually exposed to radio diagnostics in the public sector as well as in the private sector. In accordance with the recommendations of European Commission (EC) Report No. 154 [5], the dosimetric indicator used in this study to estimate the dose to the population related to medical exposure is the effective dose E (expressed in milli sievert, mSv) which is an indicator of the risk of health detriment linked to individual exposure to ionizing radiation. Being a standardized indicator, it allows comparisons between different countries and study of the evolution of the exposure that results from this or that type of act over time. Effective doses were calculated using the conversion factor values defined in ICRP Publication 60 **???**]. From the number of Nt acts and the average effective dose and associated with each type of act t, it is possible to calculate the collective effective dose S= ?Et x Nt [8]. The annual average effective dose per inhabitant is obtained by dividing the collective effective dose S by the total population size for the year studied, whether or not exposed to ionizing radiation. The statistical analysis was carried out using the software sphinx V5, Excel 2016 and the effective dose was calculated from the Internet Dose calculation Module (MICADO) online software of the National Institute for Radioprotection and Nuclear Safety (NIRNS) of France.

4 III.

5 Results

6 a) Total number of acts and collective effective dose for the population of Ngaoundéré in 2018

It is estimated that 4136 diagnostic procedures were performed in Ngaoundéré from January to December 2018. Of the 4030 patients, of whom 2394 (59.4%) were men and 1636 (40.6%) women, the sex ratio was H/F of 1.5 (Figure 1) and an average act number of 0.02 per inhabitant, 2.07% of the population of Ngaoundere performed at least one conventional imaging examination in 2018, so 0.84% women and 1.22% of men. The mean age was 37 +/-19.25 years with 1-month and 96-years extremes, the most represented age groups were 30-34 years with 378 (9.13%) cases, 35-39 years with 298 (7.20%) cases, 25-29 years with 266 (6.43%) cases, 40-44 years with 216 (5.22%) cases, 45-49 years with 214 (5.17 %) cases, and 20-24years with 202 (4.88%) cases (Table 1). The age group performing the most examination in men is 25-49 years and 25-54 years in the women. The most frequent acts involved the thorax, limbs, spine and pelvis with respectively 53.9%; 19.6%; 14.3% and 6.7% of cases (Table 2). The spine (lumbar and cervical spine), pelvic (pelvis, hip and hysterosalpingography (HSG)), skull and abdomen (intravenous urography, barium enema (BE) and abdomen without preparation (AWP) acts contributed to the majority of the collective effective dose with 39.99%, 25, 96 %, 10,53 and 8,84 % respectively, the total effective dose S resulting from all the acts is equal to 8300 mSv (Table 3).

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8 c) The most frequent acts by sex and age

The data presented in Table 4 and Figures 2 to 6 provide the following information: The exposure of patients under five years is primarily in the chest region with 23.52% for males and 30.88% for females. For limbs, 29.417%

males and 13.23% females for limbs, and skull 2,94% for males and 0% for females, no pelvic x-ray under five years. For children aged 5 to 20 years, irradiation affects the majority of limbs with 32.11% for males and 13.13% for females. For adults between 21 and 50 years old, this irradiation concerns all the most frequent acts. As early as the age of 50 years, radiation is predominant for thoracic, lumbar spine and pelvic examinations; in general, the male sex is more representative of the irradiated anatomical area. According to National Institute of Statistics (NIS) data, the population of Ngaoundere is about 200,000, which leads to an average collective effective dose of 0.04 mSv per capita in the general population. The individual average effective dose in 2018 for the population actually exposed (2.07% of the total population) is 2 mSv, according to sex 2.67 mSv in women and 1.55 mSv in men. The most irradiated age group ranges from 20 to 64 years with a dose of 4680.66 mSv (56.39%), the 30-34-year groups receive 896.76 mSv (10.80%) and 35 -39 years 706.7 mSv (8.51%) (Table 5 and figure **??**). The collective dose amount per sex is higher among women with 4487.20 mSv (54.06%) than men with 3812.98 mSv (45.94%) (Figure **??**). [8]. Indeed, the development of medical imaging is recent in the city of Ngaoundere, many equipment are outdated, operating intermittently. The high price of imaging exams relative to the average income of populations is a handicap to examinations. The low number of these examinations also makes it possible to limit the irradiation of the population. Imaging is varied across all anatomical regions with predominance of the thorax which accounts for more than half of the acts with 53.9% followed by limbs with 24.23% and the lumbar spine with 11.85%. Specialized examinations are very rare, hysterosalpingography (HSG) is 1.64%, intravenous urography (IVU) 0.34%, barium enema (BE) 0.29%, urethrocy-stography0.15 % and duodenal gactro esophageal transit (DGOT) 0.05%. The high frequency of an act takes into account its involvement in the management of common pathologies, this is the case of chest x-ray whose involvement in the management of pulmonary, cardio-mediastinal and costal pathologies is more to demonstrate. In addition this examination is strongly realized within the framework of the visits of employment, the systematic medical visits and even the visits before the registration in universities, the granting of a visa to travel in certain countries [9] which is not the case for examinations such as limbs, spine, skull whose indications are more specific and limited, often occurring in cases of trauma, pain and lameness.

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Our data are similar to those of France recorded in the National institute of Health and Medical Research report of 1994 [10] where the chest x-ray represents 31%, followed by the spine of 8.3%. As for the specialized exams, their request is rather weak because of the absence in our city of the specialists being able to request these examinations; more over they are rather expensive. Chest x-rays are found at all ages, with the limbs predominantly 0-5 years old, the pelvis predominating in adolescents up to 50 years, and the lumbar spine predominantly at the age of 50 years and more. The distribution of x-rays according to the age marries the pathologies which concern these age groups, the thoracic pathologies are found at all the ages, those of the limbs concern the children and the young adults, the pelvis and the lumbar spine mainly concern the adults. Our data corroborate those of Switzerland [11] where it was examined by x-ray of patients under five, from the thorax region, for children aged five and over, radiography mainly affects the limbs and joints for adults under 50 years, this radiation is also mainly followed by the limbs and the thorax, from 50 years. Hence, the thorax dominates.

11 b) Effective Dose

The amount of collective dose per sex is higher among women with a total of 4487.22 mSv (54.06%) compared to men with a total of 3812.96 (45.94%). Among the most irradiating examinations are the lumbar spine and the pelvis, these are examinations concerning thick areas and composed of very dense structures that require a significant load in terms of kilo voltage and milli ampere and therefore a high dose of radiation to cross them. [11].It should be noted that, the annual per capita effective dose in Ngaoundéré in 2018, equal to 0.04 mSv, is lower than the European and American average values and to the natural irradiation which is 2. **??** mSv [12]. This wide difference in dose can be explained by the presence of numerous radio diagnostic procedures including CT and nuclear medicine and a wide range of protocols by modality in these countries and also the very high number of irradiating acts in these cities compared to the city of Ngaoundere. In conventional radiology, the acts exposing the abdomen (Spine, IVU, BE and AWP), the pelvis (pelvis, hip and HSG) and the skull contribute mainly to the collective effective dose with respectively 48.83%, 25.96% and 10.53% of the collective effective dose, which is the same with data from France 2007 [8] where the acts exposing the abdomen, the pelvis and the digestive tract contribute mainly to the collective dose with 41, 5%, 29.8% and 11.8% of the collective effective dose. These are exams for which a large amount of irradiation is used and the contrast examinations are dynamic, requiring multiple incidences and shots.

V.

12 Conclusion

At the end of this study, it appears that, the medical exposure to ionizing radiation in Ngaoundere is mainly done by conventional radiology, the total number of examination is 4136 is an average number of act of 0.02 act

per inhabitant, the examinations are more frequently performed in men and the irradiation is more important for women, the most affected age groups are those aged 25 to 49 for men and 25 to 54 for women. The most common examinations are the thorax, the limbs, the lumbar spine and the skull; the most radiating examinations are the lumbar spine, the abdomen and the pelvis. The collective effective dose is 8300 mSv with 4487.22 mSv in women and 3812.96 mSv in men, an effective average dose per capita of 0.04 mSv well below European, US and natural irradiation values. The proportion of the population that has actually benefited from a conventional radiology examination is 2.07%, an individual effective average dose of 2 mSv per person.

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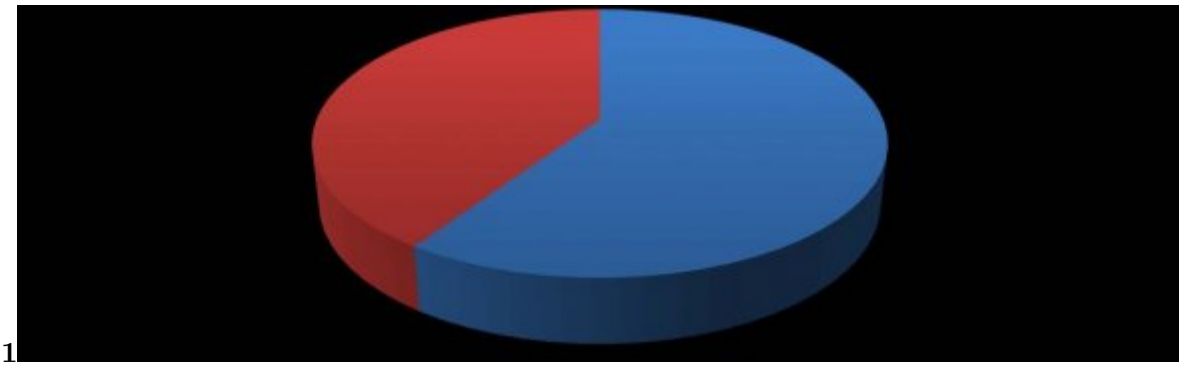

Figure 1: Figure 1 :

Figure 2: Figure 2 :

1

Age group		Frequency of act			Total	
	Male	Percentage	Female	Percentage		Percentage
0-1	16	0,39%	28	0,68%	44	1.06%
1-8	50	1,21%	38	0,92%	88	2.13%
5-9	44	1,06%	50	1,21%	94	2.27%
10-14	64	1,55%	50	1,21%	114	2.76%
15-19	72	1,74%	38	0,92%	110	2.66%
20-24	140	3,38%	62	1,50%	202	4.88%
25-29	172	4,16%	94	2,27%	266	6.43%
30-34	252	6,09%	126	3,05%	378	9.13%
35-39	176	4,26%	122	2,95%	298	7.21%
40-44	154	3,72%	62	1,50%	216	5.22%
45-49	138	3,34%	76	1,84%	214	5.17%
50-54	76	1,84%	78	1,89%	154	3.72%
55-59	82	1,98%	52	1,26%	134	3.24%
60-64	100	2,42%	68	1,64%	168	4.06%
65-69	40	0,97%	34	0,82%	74	1.79%
70-74	40	0,97%	20	0,48%	60	1.45%
75-79	10	0,24%	24	0,68%	38	0.92%
80-84	18	0,44%	18	0,44%	36	0.87%
85-89	12	0,29%	8	0,19%	20	0.48%
90-94	6	0,15%	4	0,10%	10	0.24%
95 -	2	0,05%	2	0,05%	4	0.1%
Empty	792	19,14%	620	14,99%	1412	34.14%
Total	2457	59,38%	1679	40,57%	4136	100%

[Note: b) Distribution of acts and collective effective dose byanatomical area explored.]

Figure 3: Table 1 :

2

Exams	Male	Workforce		Female	Total	
AWP	50	1,21%	28	0,68%	39	1,89%
FOREARM	62	1,50%	28	0,68%	45	2,18%
ARM	62	1,50%	50	1,21%	16	0,77%
BASIN	16	0,39%	16	0,39%	56	2,71%
ANKLE	70	1,69%	40	0,97%	55	2,66%
CLAVICLE	6	0,15%	12	0,29%	9	0,44%
ELBOW	22	0,53%	10	0,24%	16	0,77%

[Note: Volume XIX Issue II Version I D © 2019 Global Journals Exposure of the Population of Ngaoundere-Cameroon to Ionizing Radiation Related to Medical Diagnosis]

Figure 4: Table 2 :

3

Examens	Dose Collective (mSv)	Percentage
AWP	134,98	1,63%
FORE ARM	24,82	0,30%
BASIN	486,9	5,87%
ARM	4,42	0,05%
CLAVICLE	13,6	0,16%
ANKLE	13,36	0,16%
ELBOW	4,72	0,06%
FEMUR	18,16	0,22%
KNEE	26,02	0,31%
HIP	520,58	6,27%
HSG	1147,62	13,83%
LEG	33,16	0,40%
HAND	3,38	0,04%
BE	254,12	3,06%
FOOT	5,56	0,07%
WRIST	3,22	0,04%
CERVICAL SPINE	352	4,24%
DORSAL SPINE	473,54	5,78%
LUMBAR SPINE	2967,26	35,75%
SHOULDER	138,24	1,67%
URETHROCYSTOGRAPHY	74,96	0,90%
DGOT	28,50	0,34%
THORAX	346,56	4,18%
IVU	344,66	4,15%
SKULL	873,6	10,53%
TOTAL	8300	100%

Figure 5: Table 3 :

4

Exams	Thorax		Lumbar spine		Members		Pelvis			Skull
Sex	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
0-1	8	18	0	0	6	8	0	0	2	0
1-4	24	24	0	0	34	10	0	0	2	0
5-9	4	30	2	2	22	10	4	0	0	2
10-14	24	16	2	2	32	12	0	4	4	0
15-19	24	20	2	2	34	14	4	0	2	0
20-24	70	24	14	6	40	8	4	8	10	8
25-29	112	52	8	8	40	12	12	12	6	6
30-34	190	62	20	18	40	10	6	14	6	0
35-39	126	80	8	26	24	16	0	16	4	2
40-44	108	30	16	12	20	10	6	2	2	0
45-49	60	46	22	18	24	8	8	2	2	4
50-54	44	48	8	6	18	8	10	2	0	2
55-59	50	16	8	10	8	22	6	0	2	2
60-64	54	34	6	12	18	4	10	6	0	0
65-69	20	16	0	6	6	12	2	0	0	0
70-74	22	16	10	4	6	0	2	2	0	0
75-79	10	12	6	6	0	2	0	2	0	0
80-84	18	18	2	0	0	0	2	2	2	2
85-89	10	4	2	0	0	2	0	0	0	0
90-94	6	4	2	0	0	0	0	0	0	0
95-	0	2	0	0	0	0	0	0	0	0
Empty	374	296	100	114	320	242	70	74	66	44
Total	2228	868	490	252	924	410	280	146	182	72

Figure 6: Table 4 :

5

Age group		Dose (mSv)			Total	
	Male		Female			
0-1	4,76	0.06%	7,06	0.09%	11,82	0,14%
1-4	17,98	0.22%	8,3	0.1%	26,28	0,31%
5-9	32,58	0.39%	17,02	0.21%	49,6	0,60%
10-14	42,3	0.51%	109,66	1.32%	151,96	1,83%
15-19	51,98	0.63%	28,44	0.34%	80,42	0,97%
20-24	151,7	1.83%	317,18	3.82%	468,88	5,65%
25-29	218,68	2.63%	365,78	4.41%	584,46	7,04%
30-34	340,3	4.1%	556,46	6.70%	896,76	10,80%
35-39	324,32	3.91%	382,38	4.61%	706,7	8,51%
40-44	231,7	2.79%	198,16	2.39%	429,86	5,18%
45-49	340,92	4.1%	243,66	2.94%	584,58	7,04%
50-54	237,08	2.86%	100,32	1.21%	337,4	4,07%
55-59	161,18	1.94%	135,38	1.63%	296,56	3,57%
60-64	197,12	2.37%	178,34	2.15%	375,46	4,52%
65-69	58,042	0.70%	27,82	0.34%	85,86	1,03%
70-74	109,86	1.32%	38,02	0.46%	147,88	1,78%
75-79	19,38	0.23%	96,06	1.16%	115,44	1,39%
80-84	32,94	0.40%	30,7	0.37%	63,64	0,77%
85-89	15,76	0.19%	0,98	0.012%	16,74	0,20%
90-94	13,52	0.16%	0,50	0.01%	14,02	0,17%
95 -	29,94	0.36%	12,6	0.15%	42,54	0,51%
Empty	1180	14.22%	1632,4	19.67%	2812,4	33,88%
Total	3812,96	45,94%	4487,22	54,06%	8300	100%

Figure 7: Table 5 :

Figure 8:

.1 Conflicts of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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