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Knowledge and Practices of Health Professionals on the Optimization of Radiation Protection in Diagnostic Radiology in Children and Adults in the General Referral Hospitals of Bukavu in South Kivu, DRC

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Abstract

The aim of this research was to assess the knowledge and practices of radiological versus non-radiological health professionals on the optimisation of radiation protection in paediatric and adult radiology in BUKAVU hospitals. To achieve this, we surveyed a convenience sample of 73 health professionals including 23 radiologists working in the hospitals surveyed to assess knowledge and level of implementation of radiation protection principles. Also, physical parameters were taken for the calculation of entry doses in paediatric and adult radiology units for comparison with the International Commission on Radiological Protection (ICRP) diagnostic reference levels. After analysis of the data, the following was found: although radiologists have sufficient knowledge of radiation protection standards, technical constraints do not allow them to observe the dose limitation principle recommended by the ICRP. This is why several radiology departments, including those of the HPGRB, the MWANZI clinic and CIRIRI hospital, have proved to be very irradiating for children. However, radiologists and non-radiologists alike do not contribute positively to the optimisation of radiation protection in the diagnostic use of X-rays. Therefore, support in the implementation of radiation protection principles and regular monitoring of the units as well as replacement of non-standard equipment is necessary to promote patient and environmental safety by optimising radiation protection.

Keywords

Optimisation, Radiation Protection, Knowledge/Practice, Paediatric Radio, Diagnostic Reference

1. Introduction

We are naturally and constantly exposed to low doses of radiation in our environment. Humans are exposed to cosmic radiation from outer space, including the sun, as well as naturally radioactive materials in soil, water, air, food and our bodies. In addition to naturally occurring radiation, humans are also subject to man-made radiation, and X-ray machines are the most abundant source of such radiation [1].

Radiation produced by machines in the form of X-rays was developed in the late nineteenth century. Roentgen's experimental work demonstrated that X-rays could print the skeleton on a photographic plate. Applications of radiation in medicine, industry, agriculture and research expanded rapidly during the 20th century. Nuclear weapons testing, routine industrial discharges and industrial accidents have introduced man-made radioactivity into the environment. However, the use of radiation in medicine is now the largest source of man-made exposure [2].

The average annual exposure to radiation from all sources for the entire world population is about 3 mSv/year/person. On average, 80% (2.4 mSv) of the annual dose to an individual from all sources comes from radon and other natural sources of radiation (natural background), 19.7% (0.6 mSv) from the medical use of radiation and the remaining 0.3% (about 0.01 mSv) from other man-made sources of radiation. The dose received by individuals in the same population can vary greatly depending on where they live. For example, natural radiation levels vary due to geological differences and in some areas these levels can be 10 times higher than the global average [3].

Radiation protection is an important part of overall patient safety. Equipment problems, process failures and human errors in the care delivered can compromise their safety. It is an inseparable component of professional responsibility in healthcare [4].

Radiation remains the frequent and worrying cause of serious adverse events worldwide. In Chernobyl, about 1800 cases of thyroid cancer were recorded in children living in the territories close to the plant. Each year, between 120,000 and 190,000 adverse events occur during hospitalisation and between 70,000 and 110,000 admissions to institutions are caused by a preventable, radiation-related adverse event [5].

According to the 2010 report of the United Nations Scientific Committee on the Consequences of Radioactive Emissions (UNSCEAR), the total collective effective dose from medical diagnostic examinations increased by 70% between 1999 and 2009 The number of workers directly affected by work with ionising radiation (DATR) also increased by a factor of 7 and the average annual dose received by these workers increased by a factor of 1.7 during the same period according to the same report [6].

Democratic Republic of the Congo (DRC) has not escaped from this trend. In fact, over the last 20 years, the number of diagnostic and therapeutic irradiating examinations has increased and several more irradiating devices such as multi-detector scanners have been introduced in both the public and private sectors and conventional radiology examinations alone account for about 70% of the exposure to ionizing radiation in medical practice [7].

Radiation protection of patients, workers and members of the public is based on the principles of justification of practices, optimisation of exposures and limitation of doses received by workers [8] [9]. Thus, radiation protection of workers makes compliance with the principles mandatory in accordance with the recommendations of the International Commission on Radiological Protection (ICRP) [10].

In order to meet this professional obligation, health professionals, doctors and paramedics, radiologists and non-radiologists must be trained in radiation protection. Very few studies have assessed the knowledge of radiation protection among workers in the DRC.

The aim of this study was therefore to assess the knowledge and practices of radiological versus non-radiological health professionals on the optimization of radiation protection in pediatric and adult radiology in BUKAVU hospitals, more specifically to determine the role played by health professionals and their ability to respect the principle of radiation protection related to each professional category.

2. Materials and Methods

2.1. Type of Study

This is a cross-sectional study about the evaluation of the knowledge and practices of health professionals on the optimisation of radiation protection in paediatrics and adults in the general hospitals of BUKAVU in South Kivu, DRC.

2.2. Study Site

The three BUKAVU general referral hospitals were the site of our investigations. These were the BUKAVU General Referral Hospital (HPGRB), MWANZI clinic, CIRIRI General Referral Hospital and PANZI General Referral Hospital.

2.3. Target Population

Our target population was radiologists and non-radiologists working in the health structures concerned by the study.

2.4. Sampling

We surveyed a convenience sample of 73 health professionals, including 23 radiologists working in the four general referral hospitals concerned by the survey: BUKAVU General Referral Hospital, MWANZI Clinic, PANZI General Hospital and CIRIRI General Hospital. A questionnaire related to knowledge and practices on the optimisation of radiation protection in paediatrics and adults was submitted to them.

2.5. Inclusion Criteria

- To be a health professional radiologist or non-radiologist;
- To be an actual staff of the hospitals to be surveyed and to agree to answer our questions.

2.6. Parameters Studied

Apart from aspects related to the knowledge and practices of health care staff on optimising radiation protection, the following parameters were investigated for the eight examinations on the International Commission on Radiological Protection's list for paediatrics and adults: X-ray penetration (voltage in kilovolts), focal spot distance (FDF in cm); X-ray quantity in milliampere-seconds (MAS); and entrance dose. The entrance dose for each radiology department was calculated on the basis of the above radiophysical parameters of the paediatric and adult radiology examination protocol using the following formula:

$$\mathrm{DE} = 0.15 * (U/100)^2 * Q * (100/\mathrm{DFF})^2$$

where:

U is the high voltage in KV;

Q is the load in MAS;

DFF is the distance between the focus and the film.

2.7. Statistical Calculations

The entry doses obtained in each radiology unit of the hospitals concerned were compared to the ICRP diagnostic reference level (DRL) using the Student's T test, as the parameters were comparable to the matched data. The chi-square test also allowed us to analyse the proportions of health care workers in relation to knowledge and practices on the optimisation of radiation protection.

2.8. Expected Impact

The expected results will allow us to consider training or capacity building of health care workers on radiation protection on the one hand and on the other hand to conform the radio-physical parameters to the ICRP requirements in order to promote the optimisation of radiation protection for the safety of patients, the public and health care professionals.

3. Results

3.1. Status of Respondents and Institutions

Table 1 shows that many of our respondents were non-radiologists (68.5%). Table 2 shows that 75.5% of the health structures surveyed were public.

3.2. Knowledge of Radiation Protection Standards and the Effects of Radiation

In view of Table 3, there was no association between professional category and the level of knowledge of radiologists versus non-radiologists on the effects of radiation ($P > 0.005$).

Looking at Table 4, an association was found between the professional category and the level of knowledge about radiation protection standards ($P < 0.05$).

According to Table 5, there is a statistically insignificant difference between healthcare professionals with knowledge of the principle of radiation protection related to their category and those without such knowledge ($P > 0.05$).

Looking at Table 6, there was no association between professional category and knowledge of International Commission on Radiological Protection's diagnostic reference levels ($P > 0.05$).

According to Table 7, there is a statistically insignificant difference between radiologists and non-radiologists in terms of knowledge of the main source of artificial radiation ($P > 0.05$).

Table 1. Distribution of respondents by status.

Respondents	Frequency	%
Radiologists	23	31.5
Non radiologists	50	68.5
Total	73	100

Table 2. Distribution of health structures by status.

Hospitals	Frequency	%
Public	3	75
Private	1	25
Total	6	100

Table 3. Distribution of radiologist versus non-radiologist respondents according to knowledge of the effects of radiation.

Professional category	Knowledge of health personnel on the harmful effects of X-rays		Total
	Sufficient	Insufficient	
Radiologist	17	6	23
Non radiologist	29	21	50
Total	46	27	73

Table 4. Distribution of respondents according to knowledge on radiation protection standards.

Professional category	Health care workers' knowledge on radiation protection standards		Total
	Sufficient	Insufficient	
Radiologist	16	7	23
Non radiologist	10	40	50
Total	26	47	73

Table 5. Distribution of respondents according to knowledge of radiation protection principles relative to their category.

Professional category	Health workers Knowledge on radiation protection principles by professional category		Total
	Sufficient	Insufficient	
Radiologist	6	17	23
Non radiologist	25	25	50
Total	31	42	73

Table 6. Distribution of respondents according to knowledge on the ICRP DRL.

Professional category	Health workers' knowledge of ICRP DRL		Total
	Sufficient	Insufficient	
Radiologist	8	15	23
Non radiologist	18	32	50
Total	26	47	73

ICRP: International Commission on Radiological Protection; DRL: Diagnostic Reference Level.

Table 7. Distribution of respondents according to knowledge of the main source of artificial radiation.

Professional category	Knowledge of the main source of artificial radiation by health professionals		Total
	Sufficient	Insufficient	
Radiologist	9	14	23
Non radiologist	18	32	50
Total	26	47	73

3.3. Contribution to the Optimisation of Radiation Protection

According to Table 8, there was no association between the level of contribution to the optimisation of radiation protection of healthcare workers and the professional category ($P > 0.05$).

Table 8. Distribution of health professionals according to their contribution to radiation protection with regard to the appropriate principles.

Professional category	Contribution of healthcare workers to the optimisation of radiation protection		Total
	Negative	Positive	
Radiologist	10	13	23
Non radiologist	20	30	50
Total	30	43	73

3.3.1. Irradiation Level of BUKAVU Hospital Radiology Departments for Some Common Examinations, Calculated on the Basis of the Formula: $DRL/ED = 0.15 \times (u/100)^2 \times q \times (100/dff)^2$

Table 9 gives the Entry Doses calculated on the basis of the physical parameters used in the radiology department of the HPGRB for adults for some common examinations where the lumbar spine gives the high dose of 8 mGy.

Table 10 gives the calculated Entry Doses in mGy based on the data used in the paediatric radiology department of the HPGRB for some common examinations where the skull profile gives the high dose of 1.5 mGy.

Table 11 shows the Entry Doses produced by the radiology department of the MWANZI clinic for some common adult examinations.

Table 12 provides information on the Entry Doses produced by the radiology department of the MWANZI clinic for some common paediatric examinations.

Table 13 provides information on the Entry Doses produced by the radiology department at PANZI Hospital for some common adult examinations.

Table 14 explains the Entry doses produced by the radiology department at PANZI Hospital for some common paediatric examinations.

Table 15 explains the Entry Doses produced by the CIRIRI Hospital radiology department for some common adult examinations.

Table 16 gives the Entry Doses produced by the radiology department of CIRIRI Hospital for some common paediatric examinations.

3.3.2. Comparison of Doses between the Surveyed Hospitals and the ICRP Diagnostic Reference Levels (de) for Some Common Examinations

According to Table 17, there is a statistically insignificant difference between the HPGRB and the ICRP/Diagnostic Rerence Level as entry doses in adults. Therefore the service is less radiating for adults ($P = 0.123$).

According to Table 18, HPGRB Entry Doses are compared with the ICRP Diagnostic Rerence Level as entry doses in paediatrics, there is a statistically very significant difference. Thus the service is very radiative for children ($P = 0.002$).

According to Table 19, there is a statistically insignificant difference between the Entry Doses of the MWANZI Clinic and the ICRP Diagnostic Rerence Level as entry doses in adults. Thus the MWANZI Clinic radiology department is less irradiating for adults ($P > 0.05$).

Table 9. Entry doses (ED) at BUKAVU provincial general referral hospital (HPGRB) for adults.

EXAMINATION	KV	MAS	FFD	ED in Mgy
Thorax face PA	80	12.5	180 cm	0.38
Thorax in profile	90	16	180 cm	0.6
Lumbar spine font	65	63	100 cm	4
Lumber spine profile	80	80	100 cm	8
Pelvis face AP	5	63	100 cm	5
Skull face	70	40	100 cm	3
Skull in profile	65	40	100 cm	2

KV: Kilovolt; MAS: milliampere-second; FFD: Focus-film distance; mGy: milligray.

Table 10. Entry doses (ED) at the BUKAVU provincial general referral hospital (HPGRB) in paediatrics.

EXAMINATION	GAE	KV	MAS	FFD	ED in mGy
Thorax face AP	0 - 1 year	70	10	180 cm	0.23
Thorax face PA	5 years	70	12	180 cm	0.27
Thorax profile	5 years	75	12	180 cm	0.31
Skull face AP	5 years	65	32	100 cm	2
Skull in profile	5 years	60	32	100 cm	1.7
Pelvis AP	0 - 1 year	50	12	100 cm	0.45
Pelvis AP	5 ans	60	16	100 cm	1.5
ASP	5 ans	60	16	100 cm	1.5

Table 11. Entry doses (ED) at the MWANZI clinic for adults.

EXAMINATION	KV	MAS	FFD	ED in mGy
Thorax face AP	75	25	100 cm	2.1
Thorax in profile	90	40	100 cm	4.8
Lumbar spine front	90	75	100 cm	9.1
Lumbar spine profile	100	75	100 cm	11.2
Pelvis front AP	80	75	100 cm	7.2
Skull face	75	40	100 cm	3.3
Skull in profile	60	40	100 cm	2.16

Table 12. Entry doses (ED) at the MWANZI clinic in paediatrics.

EXAMINATION	AGE	KV	MAS	FFD	ED in mGy
Thorax face AP	0 - 1 year	50	10	100 cm	0.4
Thorax face PA	5 years	70	12	100 cm	0.88
Thorax in profile	5 years	75	15	100 cm	1.2

Continued

Skull face AP	5 years	75	25	100 cm	2.1
Skull in profile	5 years	85	40	100 cm	4.3
Pelvis AP	0 - 1 year	80	40	100 cm	3.8
Pelvis AP	5 years	80	40	100 cm	3.8
ASP	5 years	80	40	100 cm	3.8

AP: antero-posterior; PA: postero-anterior; ASP: unprepared abdomen.

Table 13. Doses at entry (ED) at PANZI hospital for adults.

EXAMINATION	KV	MAS	FFD	ED in mGy
Thorax face AP	120	1.6	140 cm	0.2
Thorax in profile	120	3.2	140 cm	0.5
Lumbar spine front	70	250	100 cm	11
Lumbar spine profile	70	300	100 cm	25
Pelvis front AP	70	100	100 cm	10
Skull face	70	60	100 cm	4.5
Skull in profile	70	30	100 cm	3.5

Table 14. Input doses (ED) at PANZI hospital in paediatrics.

EXAMINATION	AGE	KV	MAS	FFD	ED in mGy
Thorax face AP	0 - 1 year	90	1.6	140 cm	0.09
Thorax face PA	5 years	90	1.6	140 cm	0.09
Thorax in profile	5 years	90	2	140 cm	0.1
Skull face AP	5 years	70	20	100 cm	1.5
Skull face AP	5 years	70	16	100 cm	1.1
Skull in profile	5 years	70	12.5	100 cm	0.9
Pelvis AP	0 - 1 year	70	12.5	100 cm	0.9
Pelvis AP	5 years	70	16	100cm	1.1

Table 15. Input doses (ED) at CIRIRI hospital for adults.

EXAMINATION	KV	MAS	FFD	ED in mGy
Thorax en face AP	65	15	100 cm	0.81
Thorax in profile	80	25	100 cm	2.4
Rachis lombaire face	80	70	80 cm	11
Lumber spine profile	90	80	80 cm	15
Pelvis face AP	80	60	70 cm	12
Skull face	85	40	70 cm	8
Skull in profile	70	40	60 cm	8

Table 16. Entry doses (ED) at CIRIRI hospital in paediatrics.

EXAMINATION	AGE	KV	MAS	FFD	ED in mGy
Thorax face AP	0 - 1 year	50	10	100 cm	0.4
Thorax face PA	5 years	50	12	100 cm	1.5
Thorax in profile	5 years	40	15	100 cm	0.4
Skull face AP	5 years	50	25	100 cm	1.5
Skull in profile	5 years	40	40	100 cm	2
Pelvis AP	0 - 1 year	80	40	100 cm	6
Pelvis AP	5 years	70	20	100 cm	3
ASP	5 yaers	80	20	100 cm	7

Table 17. Comparison of the HPGRB's entry doses (ED) with the diagnostic reference levels of the international commission on radiological protection diagnostic reference levels for adults.

EXAMINATION	ED/HPGRB/ADULTS	DRL(ED)/ICRP/ADULTS
Thorax face AP	0.38	0.3
Thorax in profile	0.6	1.5
Lumbar spine face	4	10
Lumbar spine profile	8	30
Pelvis face AP	5	10
Skull face	3	5
Skull in profile	2.16	3

Table 18. Comparison of HPGRB entry doses (ED) with the international commission on radiological protection in paediatrics diagnostic reference levels.

EXAMINATION	AGE	ED/HPGRB/PAED	DRL(ED)/ICRP/PAED
Thorax face AP	0 - 1 year	0.23	0.08
Thorax face PA	5 years	0.27	0.1
Thorax in profile	5 years	0.31	0.2
Skull face AP	5 years	2	1.5
Skull in profile	5 years	1.7	1
Pelvis AP	0 - 1 year	0.45	0.2
Pelvis AP	5 years	1.5	0.9
ASP	5 yaers	1.5	1

According to Table 20; there is a statistically significant difference between the Entry Doses of the MWANZI clinic and the Diagnostic Reference Level (Entry Doses) of the ICRP in paediatrics. Thus, the service is very irradiating in paediatrics at the MWANZI clinic ($P < 0.05$).

From Table 21, the difference between the Entry doses of PANZI Hospital

Table 19. Comparison of the MWANZI clinic's entry doses (ED) with the international commission on radiological protection's diagnostic reference levels for adults.

EXAMINATION	ED/MWANZI CLINIC/ADULTS	DRL(ED)/ICRP/ADULTS
Thorax face AP	2.1	0.3
Thorax in profile	4.8	1.5
Lumbar spine face	9.1	10
Lumbar spine profile	11.2	30
Pelvis face AP	7.2	10
Skull face	3.3	5
Skull in profile	2.16	3

Table 20. Comparison of MWANZI clinic's entry doses (ED) with the international commission on radiological protection's diagnostic reference levels in paediatrics.

EXAMINATION	AGE	ED/CLINIC MWANZI/PEAD	DRL(ED)/ICRP/PEAD
Thorax face AP	0 - 1 year	0.4	0.08
Thorax face PA	5 years	0.9	0.1
Thorax in profile	5 years	1.7	0.2
Skull face AP	5 years	2.1	1.5
Skull in profile	5 years	4.3	1
Pelvis AP	0 - 1 year	4	0.2
Pelvis AP	5 years	4	0.9
ASP	5 years	4	1

Table 21. Comparison of PANZI hospital entry doses (ED) with the international commission on radiological protection diagnostic reference levels for adults.

EXAMINATION	ED/PANZI HOSP/ADULTS	DRL(ED)/ICRP/ADULTS
Thorax face AP	0.2	0.3
Thorax in profile	0.5	1.5
Lumbar spine face	11	10
Lumbar spine profile	25	30
Pelvis face AP	10	10
Skull face	4.5	5
Skull in profile	3.5	5

and the Diagnostic Reference Level of the ICRP in adults is statistically insignificant. However, the service is less irradiating for adults ($P > 0.05$).

Table 22 shows that there is a statistically insignificant difference between the Entry Doses for PANZI Hospital and the Diagnostic Reference Level for the ICRP in paediatrics. Thus, the service is less radiating in paediatrics in PANZI ($P > 0.05$).

From Table 23, there is a statistically insignificant difference between the CIRIRI Hospital Entry Doses and the ICRP Diagnostic Reference Level for adults. The service is less irradiating for adults ($P > 0.05$).

Looking at Table 24, there is a statistically significant difference between CIRIRI hospital's Entry Doses in paediatrics and the ICRP's Diagnostic Reference Level in paediatrics. The service is radiating for children in CIRIRI hospital ($P < 0.05$).

Table 22. Comparison of the entry doses (ED) of the PANZI hospital with the diagnostic reference levels of the international commission on radiological protection in paediatrics.

EXAMINATION	AGE	ED/PANZI/PAED	DRL(ED)/ICRP/PAED
Thorax face AP	0 - 1 year	0.09	0.08
Thorax face PA	5 years	0.09	0.1
Thorax in profile	5 years	0.1	0.2
Skull face AP	5 years	1.5	1.5
Skull in profile	5 years	1.1	1
Pelvis AP	0 - 1 year	0.9	0.2
Pelvis AP	5 years	0.9	0.9
ASP	5 yaers	1.1	1

Table 23. Comparison of CIRI hospital's entry doses (ED) with the international commission on radiological protection's diagnostic reference levels for adults.

EXAMINATION	ED/CIRIR HOSP/ADULTS	DRL(ED)/ICRP/ADULTS
Thorax face AP	0.81	0.3
Thorax in profile	2.4	1.5
Lumbar spine face	11	10
Lumbar spine profile	15	30
Pelvis face AP	12	10
Skull face	8	5
Skull in profile	8	3

Table 24. Comparison of CIRI hospital's entry doses (ED) with the international commission on radiological protection's diagnostic reference levels in paediatrics.

EXAMINATION	AGE	ED/PANZI/PAED	DRL(ED)/ICRP/PAED
Thorax face AP	0 - 1 year	0.4	0.08
Thorax face PA	5 years	1.5	0.1
Thorax in profile	5 years	0.4	0.2
Skull face AP	5 years	1.5	1.5
Skull in profile	5 years	2	1
Pelvis AP	0 - 1 year	6	0.2
Pelvis AP	5 years	3	0.9
ASP	5 years	7	1

4. Discussion of the Results

4.1. Status of Respondents and Structures

Many of our respondents were non-radiologists, *i.e.* 68.5%; this distribution was made possible by the weighted stratified sampling proportional to the number of staff in each category. Also 75% of the structures surveyed were state-owned (Table 1, Table 2).

4.2. Knowledge of Radiation Protection Standards and the Effects of X-Rays

Tables 3-6 show that there is a statistically insignificant difference between the proportion of radiologists who know about the effects of radiation compared to the other categories.

Radiologists with sufficient knowledge of radiation protection standards have a high proportion compared to other health professionals.

The majority of radiologists and non-radiologists alike are unaware of the diagnostic reference levels or entry doses for some common examinations given by the International Commission on Radiological Protection.

According to Table 6, only 34.5% of the radiologists surveyed know the diagnostic reference levels, while 64% do not. On the non-radiologist side, 36% were aware of the International Commission on Radiological Protection's entry dose levels compared to 64% who were unaware of them.

Although these entry doses are calculated on the basis of data resulting from the radiophysical parameters used in the different radiology departments, it is of great importance that practitioners are aware of the ICRP diagnostic reference levels as an indicator for assessing the degree of irradiation in their department [3].

The truth is that the technical constraints related to the lack of maintenance and lack of controlling equipment quality by radiophysics specialists push most radiologists to produce even irradiating doses with the probability of repeating examinations, even though the radiation protection standards advise against it.

The data in the three tables above are similar to those obtained by Health Canada in its 2015 report on radiation exposure in Canada [9].

4.3. Contribution to the Optimization of Radiation Protection

Table 8 shows that there is a statistically insignificant difference between the proportion of radiologists who contribute positively to optimizing radiation protection in the diagnostic use of X-rays and those who do not.

Thus, only 56% of radiologists provide technical conditions that allow for dose limitation in their work. In view of this finding, radiation remains a real problem in BUKAVU hospitals. The results of Table 10 are significantly different from those found by Abbat, Lakey and Mathias in their study conducted in France on protection against radiation [11]. The survey carried out by the latter showed that radiologists as well as prescribers or applicants for examinations contribute in their great majority to the limitation of doses in the diagnostic use of X-rays.

Tables 9-16 give the different radio physical indices (voltage in KV, charge in MAS and focal spot to skin distance in Cm) which allowed us to calculate the doses at the entrance of the body for some common examinations in adults and children using the formula: $0.15 \times (U/100) \times Q \times (100/\text{DFP})$ [12].

As can be seen, these different radio physical indices vary according to the service, the level of maintenance and regular control of the service. For our study the brand does not matter as our main concern is the dose rate or input dose for each examination in both adults and paediatrics.

4.4. Comparison of the ICRP Entry Doses with the Entry Doses Produced in BUKAVU Hospitals

According to Table 17 and Table 18, there is a statistically insignificant difference between the entry doses produced by the radiology department of the BUKAVU Provincial General Reference Hospital and those of the ICRP for adults. As can be seen, the EDs of the HPGRB are slightly higher than or equal to those of the ICRP for adults for some common examinations.

This being the case, the HPGRB radiology department does not irradiate adults, all other things being equal. These data are similar to those found by Duriez in his study on the production of X-rays and their application in medical and industrial radiography.

On the other hand, for the data in Table 18, there is a statistically significant difference between the input doses produced by the HPGRB and those of the ICRP in paediatrics for some common examinations. In this respect, the radiology department of the HPGRB was found to be very irradiating for children. This finding is bitter because, as we have pointed out, children are among the people for whom particular attention must be paid to their protection against radiation, especially as in children the sensitive organs are closer to the part to be radiographed.

According to Table 19 and Table 20, a statistically insignificant difference was recorded between the entry doses of the radiology department of the MWANZI clinic for some examinations in adults. Thus the department is less radiating for adults but very radiating for children as the difference is statistically significant between the data used by the MWANZI clinic in paediatrics and that of the ICRP. The data or input doses produced by the MWANZI clinic radiology department are very high compared to the ICRP paediatric input data for the same examinations [13].

This is an unfortunate finding because in children, tissues develop rapidly and sensitive organs are closer to the part to be radiographed and also these organs must be subject to better and more effective radiation protection even in the case of a less irradiating radiology department.

Table 21 and Table 22 show a statistically insignificant difference between the input data or doses produced by the radiology department of PANZI Hospital and those of the ICRP in adults for some examinations. In terms of this result, the PANZI radiology department is less radiating for both children and adults. These results are similar to those obtained by Davenport MS, Cohan RH. Caoili EM in their study of X-ray devices for diagnostic use and baggage inspection-precautions in Canada [14].

The good results given by PANZI Hospital would be due to the regular monitoring that the radiology department receives.

According to **Table 23** and **Table 24**, there is a statistically insignificant difference between the CIRIRI hospital's entry doses and those of the ICRP for adults for the same examinations. On the other hand, a statistically significant difference was observed between the CIRIRI hospital entry doses for children and the ICRP entry doses. The CIRIRI radiology department is radiating to children.

The observation is generally deplorable because out of four radiology services in the major health structures in BUKAVU, three (75%) offer radiology services that are irradiating to children. However, according to the statistics, out of 100% of radiology examinations prescribed, 40% are for children and one can imagine the degree of irradiation for these children, for the public and for the environment. Also, as the service is irradiating, there is unfortunately the possibility of doing an examination more than once for the same cause with the risk of doubling the dose because X-rays have cumulative effects.

At a time when the world is advocating the reduction of the intense production of greenhouse gases, which is a measure of radioprotection against natural irradiation, it is imperative that the optimisation of radioprotection against the abundant and main source of artificial irradiation be put in place because the effects caused by the two sources of irradiation are almost similar.

5. Conclusions

Medical imaging is, among many others, a health discipline based on scientifically complex methods and techniques, but the evolution of technology today brings many alternatives in most diagnostic fields, including radiology.

Medical imaging equipment is an indisputable source of radiation or artificial irradiation and today the anarchic proliferation of radiology services in the city of BUKAVU constitutes a good for the population and a danger for the environment in the event of non-respect of radiation protection standards. It is with this in mind that we decided to carry out a study to assess the level of knowledge and practices of health professionals on the optimisation of radiation protection in the face of the diagnostic use of X-rays in BUKAVU's general referral hospitals.

This research allowed us to observe that radiologists, although they have sufficient knowledge of radiation protection standards, technical constraints do not allow them to observe the principle of optimisation recommended by the International Commission on Radiological Protection. This is why several departments, including those of the HPGRB, the MWANZI Clinic and CIRIRI Hospital, have been found to be highly irradiating to children. Radiologists and non-radiologists alike do not contribute positively to the optimisation of radiation protection in the diagnostic use of X-rays.

Therefore, training in radiation protection, support in the implementation of radiation protection principles, and regular monitoring of the K-NRC's radiation physics units, as well as the replacement of non-standard equipment, are necessary to promote patient and environmental safety through the optimisation of radiation protection.

Conflicts of Interest

There is no conflict of interest for this paper.

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