European Journal of Radiology Open 7 (2020) 100287

Contents lists available at ScienceDirect

European Journal of Radiology Open

journal homepage: www.elsevier.com/locate/ejro

Knowledge of radiation protection among radiology professionals and students: A medical college-based study

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HIGHLIGHTS

- The overall knowledge of radiation protection among radiology professional and students was adequate.
- The knowledge of radiation protection among diploma graduate was inadequate.
- Radiation protection law should be promulgated as soon as possible in Nepal.
- This is the first study to perform principal component analysis in the research study of its kind.

ARTICLE INFO

Keywords:
Radiation awareness
Radiology
Radiography
Radiation protection
Nepal

ABSTRACT

BACKGROUND: Radiation protection is the core of radiography for safe radiation-based imaging practice. This study aims to determine the knowledge of radiation protection among radiology professionals and students in a medical college of Nepal.

MATERIAL AND METHODS: A questionnaire survey was carried out among 35 radiology staff and students at Universal College of Medical Sciences (UCMS), Bhairahawa, Nepal. The questionnaire survey consisted of socio-demographic variables and 17 questions, 3 questions were related to general information regarding training, knowledge, and experience and the remaining 14 multiple choice questions (MCQ) were related to radiation protection. Data were analyzed in SPSS Statistics software, version 27. The *p*-value was set at 5% level of significance. Nonparametric tests were applied since the data did not follow normal distribution. The knowledge score were categorized into lesser than 60 % inadequate, 60–80 % adequate and greater than or equal to 80 % excellent.

RESULTS: Out of total 35 participants, 28 were male and 7 were female with mean age 26.09 ± 7.18 years, range 18–54. The average radiation level of awareness was 9.6 (68.57 %), which was adequate, maximum 13 and minimum 4. There was not statistical significance of knowledge score by gender, age groups, work experience and studentship. Taking academic qualification, the level of knowledge of diploma graduates was inadequate 7.76 (55.42 %), and lower than other higher academic qualifications.

CONCLUSIONS: Adequate radiation protection course materials and training should be introduced for diploma graduates. Continuing professional education (CME) should be organized regularly. Moreover, radiation protection law is a must in Nepal now.

1. Introduction

Ever since the discovery of X-rays by Wilhelm Conrad Roentgen in 1985, the use of ionizing radiation in the field of medicine has been rapidly increasing, which is attributable to recent advancements in imaging technology, that are promising in solving wide array of clinical problems [1,2]. While the use of ionizing radiation has revolutionized the medical field, it is a double-edged sword since it is a potential source

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https://doi.org/10.1016/j.ejro.2020.100287
Received 6 September 2020; Received in revised form 29 October 2020; Accepted 1 November 2020

of health hazard [3]. Radiation accidents have enabled the study of effects of high level of radiation, and linear-no-threshold (LNT) model for radiation risk assessment has been established, according to which radiation dose above zero poses risk to a certain extent [4]. Although some consider that concept of LNT based risk estimation is wrong attributing it to unnecessary fear among people and increased expenditure on safety measures, it is still the basis for radiation regulation [5,6]. Moreover, recent studies have shown carcinogenic potential of low dose ionizing radiation from medical imaging [7,8]. Thus, sensible and optimized use of radiation is of utmost importance [9]. Optimization of radiation in medical imaging is achieved through the collective effort of the referring physician, radiologist, radiologic technologist/radiographer, other staffs who are directly or indirectly involved in the imaging technique and the patient himself [10]. Referring physician should always ensure that the use of ionizing radiation is justified i.e. benefits of radiation should outweigh the risk [11]. It is also the duty of radiologist and radiographers to check whether the examination is obligatory [12]. Since they are formally educated, they are supposed to have thorough knowledge on safety measures and optimization techniques [10]. It is their responsibility to spread awareness regarding wise use of radiation not only among other staffs in radiology department but also among the patients and the public [10]. Therefore, radiation awareness is a must to ensure rational use of ionizing radiation in medicine [13].

The history of medical use of radiation in Nepal dates back to 1923 when the first X ray machine was installed [14]. New set ups are being established and radiation workers are constantly being produced through various academic programs. While the field of radiology in terms of academics is growing strong, there is still no radiation act in Nepal [14]. According to IAEA, it is essential for each nation to have radiation and nuclear safety authority in order to prevent repercussions arising from radiation safety issues from one country to other countries [15]. In the absence of radiation protection authority, Nepal is facing a huge challenge in terms of radiation protection [14]. Radiation awareness among radiation workers and public play even stronger role in conditions where there is no regulatory body. However, many studies done worldwide have shown that radiation protection knowledge in radiation workers does not meet the standard [16–19]. Very few studies have been done to assess radiation awareness among radiation workers of Nepal. These studies have shown that the level of knowledge is not adequate to ensure radiation safety, and radiation protection issue is still not taken into serious consideration [20,21].

The main aim of this survey-based study was to determine the knowledge of radiation protection among staffs and students in radiology department of one of the medical colleges of Nepal.

2. Methods

2.1. Questionnaire

A questionnaire survey was performed to obtain a snapshot of knowledge of radiation protection among radiology professionals (radiologist, medical physicist, medical imaging faculty, technologist, and radiographers), residents and students. The survey included demographic characteristics (age, gender, academic qualification, and work experience) and multiple choice questions (MCQ) related to radiation protection. 17 questions were administered to each participant, 3 questions were related to general information regarding training, knowledge, and experience of medical radiation imaging. The remaining 14 multiple choice questions (MCQ) measured the level of understanding of radiation protection. The questionnaire survey was conducted at the Department of Radio-Diagnosis & Medical Imaging, Universal College of Medical Sciences (UCMS), Bhairahawa, Nepal. UCMS is a pioneer institute in medicine, allied health sciences, nursing and dentistry, affiliated with Tribhuvan University (TU), recognized by Nepal Medical Council (NMC).

3. Data collection

All the staff and students of the Department of Radio-Diagnosis & Medical Imaging participated in the survey. The data were collected from 1st to 10th October 2015. The department comprises of Radiologist, Medical Physicist, Medical Imaging faculty, Radiologic Technologist, Radiographers, MD Radio-diagnosis residents and undergraduate students of medical imaging technology. Participants were handed out the hardcopy questionnaire survey by the principal investigator himself and were requested to complete in front of the investigator. Each correct answer was given "1″ score and for negative answers, there was no negative markings.

4. Data analysis

Data were inserted into SPSS statistical software, version 27, IBM, Chicago, United States. A descriptive analysis and statistical tests were performed. The knowledge of radiation protection was categorized as inadequate <60 %; adequate 60–80 % and excellent 80–100 %. The normality of the data was checked by using Shapiro-Wilk test. The equality of variance was assessed by Levene's test. Non-parametric tests, namely Mann-Whitney *U* test and Kruskal-Wallis H-test were used for statistical analysis since the data did not follow normal distribution. Pairwise post-hoc test with Bonferroni correction was applied for statistically significant findings obtained from Kruskal-Wallis H-test. The p-value$\leq$0.05 was considered as statistically significant.

Principal Component Analysis (PCA) was used to reduce the dimensionality of the 14-questionnaire responses into first two components. The first two components were visualized graphically using *"ggbiplot"* library. PCA was applied using *prcomp()* function in RStudio, an integrated development environment (IDE) for R programming language, Boston, Massachusetts, United States [22]. The results of the PCA analysis is enclosed as a supplementary file. To our best knowledge, this is the first study of its kind that used PCA analysis.

An ethical consent of approval was obtained from the local institutional review board (IRB) of Universal College of Medical Sciences, Bhairahawa, Nepal. A written informed consent form to participate was obtained from each participate, and the anonymity of the participants was completely ensured.

5. Results

Of 35 participants, 28 were male and 7 were female, with mean age 26.09 $\pm$ 7.18 years. 37.1 % (n = 13) were students and 62.9 % (n = 22) were included in this study. The demographic information of the participants is demonstrated in Table 1.

Out of 14 questions, the maximum and minimum scores obtained were 13 and 4 respectively. The average radiation awareness was 9.6 (68.57 %). Each participant stated that they had taken formal education (lecture or training course) related to the radiation protection. 6 participants (17.14 %) stated that they had inadequate knowledge about risk of radiation and radiation safety, whereas all the participants had clinical posting or job experience in x-ray related procedures. The correct response for each question is listed in Table 2.

Table 3 shows the distribution of the knowledge score by demographic information. Mann-Whitney *U* test resulted that the knowledge score was same across categories of gender, $U = 75.50$, $p > 0.05$. Kruskal-Wallis H test demonstrated that the knowledge score was same across age groups, $\chi2(3) = 7.35$, $p > 0.05$. However, the knowledge score was statistically significant according to academic qualifications, $\chi2(5) = 16.43$, $p < 0.05$. Pairwise post-hoc comparison test with Bonferroni correction showed that diploma graduates and MD radiodiagnosis residents have different knowledge score at $p < 0.05$. According to Table 3, the lowest average knowledge level was 7.76 (55.42 %) for diploma graduates, whereas the highest average knowledge level was 13.00 (92.85 %) for medical physicist. There was a same

Table 1
Demographic Characteristics.

Demographic Characteristics	Frequency	Percentage (%)
Gender		
Male	28	80.0
Female	7	20.0
Age Groups (in years)		
≤ 20	11	31.4
20 – 25	6	17.1
25 – 30	11	31.4
≥ 30	7	20.0
Academic Qualification		
Diploma Graduate	17	48.6
BSc MIT Student	5	14.3
BSc MIT Graduate	2	5.7
MDRD Resident	8	22.9
MDRD Graduate	2	5.7
Medical Physicist	1	2.9
Work Experience		
Yes	12	34.3
No	23	65.7
Student		
Yes	13	37.1
No	22	62.9

Table 2
Correct response of the questionnaire survey.

SN	Questions	Frequency of correct answer	Percentage (%)
1.	SI unit of absorbed dose equivalent	10	28.5
2.	CT scan involves the usage of x-rays	29	82.8
3.	Material of protective cloth for x-ray examination	23	65.7
4.	Mammography involves the usage of x-rays	34	97.1
5.	Standard minimum safe distance from x-ray machine while performing portable x-rays	21	60.0
6.	Highest permitted level of occupational radiation dose	23	65.7
7.	MRI involves the usage of x-rays	25	71.4
8.	If fluoroscopy is on, and if you are not operating or assisting in the procedure, do you step out of the room?	26	74.2
9.	Ultrasound involves the usage of x-rays	31	88.5
10.	SI unit for measurement of radioactivity	16	45.7
11.	Radiation is present inside CT scanner all the times 24 h a day	27	77.1
12.	Probability for risk of cancer after undergoing a chest x-ray examination	24	68.5
13.	Pregnant nurse can work in fluoroscopy in first trimester	19	54.2
14.	Gamma rays are used for medical purpose	28	80.0

distribution of knowledge according to experience, $U = 171.00\ p > 0.05$. However, the knowledge score was higher in students than non-students, $U = 69.50\ p < 0.05$.

6. Discussion

The main aim of this study was to assess the knowledge of radiation protection among radiology professionals and students in a medical-college setting. This is a paramount study that highlight the awareness of radiation protection in a private institution in Nepal. Previously, Maharjan has also carried out similar study and resulted adequate knowledge among radiographers and radiography students participated in an annual conference of Nepal Radiological Society (NRS) [20]. Jha *et al.* also concluded average knowledge, poor perception and satisfactory practices of radiation risk among technical and non-technical staff of radiology department and stressed the malpractice of x-radiation imaging [23]. In this present study, the mean radiation awareness was 68.57 % which was adequate. The level of knowledge regarding radiation protection among diploma graduates was 7.76 (55.42 %). This implied that the diploma graduates were not aware of the radiation protection. There is a substantial need for diploma graduates to improve their awareness of radiation protection issues. Furthermore, the level of knowledge of students was higher than the non-students, that implied lack of update of radiation protection courses among working staff. Specific regular training courses should be designed at regular time interval at institutional and national level [24]. Several literature papers have also concluded a substantial need for radiographers to improve their awareness regarding radiation protection issues [24–26], greater emphasis should be given during study period [16–18]. In-service training for medical health workers should be provided with up-to-date study documents with adequate radiation protection training protocols and guidelines should be mandated [27]. Further work is required to justify the specific dose limits and the implementation of national protection legislation focusing on patient's safety can be linked with radiography practice [26].

Table 3
Mean knowledge score with statistical significance.

Variables	Knowledge Score	*p*-value
Gender		
Male	9.68	0.362
Female	9.29	
Age Groups (in years)		
≤ 20	8.09	0.061
20 – 25	9.00	
25 – 30	10.64	
≥ 30	10.86	
Academic Qualification		
Diploma Graduate	7.76	0.006[a]
BSc MIT Student	11.20	
BSc MIT Graduate	11.00	
MDRD Resident	11.13	
MDRD Graduate	12.00	
Medical Physicist	13.00	
Work Experience		
Yes	10.50	0.263
No	9.13	
Student		
Yes	11.15	0.011
No	8.68	

[a] Statistically Significant.

Radiographers are the last patron of unnecessary radiation dose. Radiation protection is the professional heart core of the radiographers. If the radiographers are not fully aware of the radiation protection, they might irradiate patients with unjustified radiation dose [24]. It is not to forget that the hazards of ionizing radiation were recognized within one year of discovery of X-rays. Ever since, there has been concern over the safe use of radiation. The concern has raised even more now since use of ionising radiation in medicine is increasing at an alarming rate. Radiation protection bodies have been established that set the guidelines to ensure justified and optimum use of radiation [15]. Technologies have been improved with an aim to monitor and control radiation exposure to patient, public and radiation workers while maintaining the image quality. Radiation protection knowledge among the staff of radiology department should be given more importance than ever. Radiation workers have full control over the radiological procedures, and it is their responsibility not to misuse radiation. Therefore, it is the matter of utmost importance that each radiation worker knows what he is doing. A radiologist should always confirm that an examination involving ionizing radiation is justified. Similarly, a radiographer should always follow safe radiation practice.

Even though this study was conducted in one of the least developed

country in the world, Nepal, having miniscule resources for radiation safety and dosimetry, the results showed adequate knowledge despite an obvious substandard quality of radiography education compared to developed countries. Subedi *et al.* [21] also highlighted radiation protection is a very much neglected issue in Nepal till date though x-rays have been in medical imaging use from nine decades ago. They also stressed an urgent need for quality assurance and safety for emerging immense hurdles. Adhikari *et al.* [14] also performed radiation survey and noticed that 65 % of the radiation workers had never been monitored for radiation and the quality control tests were missing in all diagnostic hospitals. Though Nepal is a member of International Atomic Energy Agency (IAEA), still the government of Nepal and the authorized organizations have not taken appropriate steps to improve the present situation. It is pitying that Nepal has not enacted radiation protection and safety laws to the patients and radiation workers. Mounting adverse effects of radiation in Nepal and the present situation of COVID-19 pandemic has created a miserable situation. To uplift the present situation, it is high time that government of Nepal in collaboration with international monumental organizations, local stakeholders, radiological technology educators should take appropriate attention. Though regular training, workshop, seminar, and conference would firmly raise provide awareness on radiation protection, the authors expect the promulgation of legal laws of proper practice of radiation would prove to be a milestone for beginning this arduous task.

This may not be the first study performed regarding the awareness of radiation protection in Nepal, but we presume the study will play a crucial role in improving the situation of radiation protection in Nepal, considering the study was conducted in private institution. Though the results demonstrated adequate knowledge, the authors expect the improvement of knowledge of radiation protection among diploma graduates by inserting adequate radiation protection modules in diploma study curriculum.

6.1. Limitations of the study

This study was conducted in single institution with a small sample ($n = 35$) and therefore cannot be considered as representative of whole nation. A larger sample from different institutions could have enhanced the results. Future studies should be carried out among medical doctors, dentists, referral physicians, nurses and other workers to determine the total radiation protection knowledge level in a hospital who are directly or indirectly related to radiology field.

7. Conclusion

We recommend that radiation protection and safety training should be a part of mandatory training for radiology professionals, especially for diploma graduates. Ample radiation protection modules should be introduced in the curriculum of diploma level. Regular Continuing Professional Education (CPE) should be organized and implemented through collaboration between national and international organizations with the involvement of government representatives and hospital administration. Radiation protection, being a multi-sectoral field, every aspect should join hands to raise awareness about it. To sum up, radiation protection law is an uttermost importance in Nepal at present.

Authors Contribution

Surendra Maharjan has a contribution in research conceptualization, research design, data collection, data analysis, results interpretation, original draft writing, final draft writing, and revision of the manuscript.

Kalpana Parajuli has a contribution in research conceptualization, research design and initial draft writing.

Suraj Sah has a contribution in research conceptualization, and research design.

Upakar Poudel has a contribution in data collection.

Ethical statement

Hereby, I, Surendra Maharjan consciously assure that for the manuscript /insert title/ the following is fulfilled:

1) This material is the authors' own original work, which has not been previously published elsewhere.
2) The paper is not currently being considered for publication elsewhere.
3) The paper reflects the authors' own research and analysis in a truthful and complete manner.
4) The paper properly credits the meaningful contributions of co-authors and co-researchers.
5) The results are appropriately placed in the context of prior and existing research.
6) All sources used are properly disclosed (correct citation). Literally copying of text must be indicated as such by using quotation marks and giving proper reference.
7) All authors have been personally and actively involved in substantial work leading to the paper, and will take public responsibility for its content.

Financial competing interest

Nil.

Availability of data materials

The data and R programming codes will be provided upon reasonable request to the corresponding author.

Declaration of Competing Interest

Nil.

Acknowledgement

Authors would like to thank all the radiology staff and students who actively participated in this survey.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.ejro.2020.100287.

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