Assessment of the Practice of Radiation Safety Principles among Radiological Professionals in Mongolia

Odonchimeg Purev¹, Manduul Enkhjargal²,³, Shota Ogawa⁴, Tugsjargal Purevsukh², Munkhbaatar Dagvasumberel⁴, Batgerel Oidov⁵, Ayako Taketomi-Takahashi¹, Yoshito Tsushima¹,⁶, Akira Iwase¹ and Hiromitsu Shinozaki⁷,⁸

¹ Gunma University Graduate School of Medicine, 3-39-22 Showa-machi, Maebashi, Gunma 371-8511, Japan
² Nuclear Medicine Centre, Second State Central Hospital, Bayanzurkh District, 3rd Khoroo Peace Avenue 49, Ulaanbaatar 13381, Mongolia
³ Department of Radiology, School of Medicine, Mongolian National University of Medical Sciences, Zorig Street, Ulaanbaatar 14210, Mongolia
⁴ Mie University Graduate School of Medicine, 2-174 Edobashi, Tsu, Mie 514-8507, Japan
⁵ Department of Administration, Third State Central Hospital, Bayangol District, Ard Ayush 1a Street, Ulaanbaatar 16081, Mongolia
⁶ Gunma University Initiative for Advanced Research (GIAR), Gunma University, 3-39-22 Showa-machi, Maebashi, Gunma 371-8511, Japan
⁷ Gunma University Graduate School of Health Sciences, 3-39-22 Showa-nachi, Maebashi, Gunma 371-8514, Japan

Abstract
Objective: To investigate the association between the practice of radiation safety principles (PRSP) and participation in radiation safety refresher courses among Mongolian radiology professionals.
Methods: This cross-sectional questionnaire-based study was conducted in Ulaanbaatar, Mongolia. The questionnaire was distributed to 250 participants, and 156 questionnaires were analyzed.
Results: Only 59.6% of radiologists and 59.8% of technicians used lead aprons regularly. Less than half of the professionals tried to minimize the time of the procedure (28.8% and 28.3%) and to distance themselves from the X-ray source (42.9% and 37.0%). The professionals who participated in radiation safety refresher courses had practiced the safety principles better than those who had not (p = 0.028).
Conclusion: In Mongolia, many radiology professionals did not practice proper radiation protection, but participation in radiation safety refresher courses was effective. Besides the importance of personal protective equipment supplies, further education and training for radiation safety for the professionals are required.

Introduction
X-ray examinations should be performed with optimum image quality to ensure effectiveness. The minimum possible radiation dose must be used to minimize radiation exposure not only to the patients, but also to the radiology professionals.¹³ In this regard, education on the proper use of radiological examination and radiation protection is indispensable.

In Mongolia, the most common application of ionizing radiation is in the health sector. X-rays have been used for diagnosis in Mongolia since 1934, and the number of radiologists has increased from 89 in 2000 to 521 in 2018.⁴⁵ In addition, the number of technicians increased from 244 in 2000 to 625 in 2018.⁵ Radiation safety principles have been introduced, and a legislation was passed to define the limit and to establish regulations for radiological protection of medical professionals and patients.⁶ The development of sustainable education and training infrastructure for medical professionals, regarding radiation safety, should be considered an important component in the national strategy for building competence in radiation protection and safety.⁷ However, there have been very few studies on radiation safety in the Mongolian setting.

This study aimed to investigate the association between the practice of radiation safety principles (PRSP) and participation in radiation safety refresher courses among Mongolian radiology professionals.
Radiation safety principles in Mongolia

Materials and Methods

Study period and population
This cross-sectional questionnaire-based study among radiology professionals was conducted in October 2018 in Ulaanbaatar, Mongolia, at the Mongolian Congress of Radiology. The questionnaire was distributed to 250 participants. Individuals were from two professional groups: radiologists and technicians working in radiology departments in Mongolia. The recruitment process was illustrated in Fig. 1.

Questionnaire design
The questionnaire (Fig. 2) consisted of two parts. Part 1 included demographic information: age, sex, occupation, experience, participation in radiation safety refresher courses within the last 3 years, and frequency of imaging examinations. Part 2 was designed with reference to the “as low as reasonably achievable (ALARA)” practical guidebook and consisted of six questions to explore the participants’ PRSP during their clinical work.

The first four questions of Part 2 assessed the usage frequency of personal protective equipment (PPE). The fifth question assessed adherence and non-adherence to minimization of the procedures’ time. The last question assessed whether the professionals distanced themselves from the X-ray source.

The Practice Score of Radiation Safety Principles (PSRSP) was assessed, which scores a participants’ frequency of PPE usage (regular use, 1 point; non-regular use, 0 points), procedure time minimization (adherence, 1 point; disregard, 0 points), and distance from the X-ray source (adherence, 1 point; disregard, 0 points). Moreover, PSRSP score provided 4 type of PPE usage: lead aprons, thyroid shields, leaded gloves, and leaded eyeglasses.

Statistical analysis
The data were analyzed using SPSS Statistics for Windows (ver. 25; IBM, Armonk, NY). All variables were summarized and reported using statistics with numbers and percentages. Fisher’s exact test was used to examine the association of PRSP with age, sex, length of service, participation in radiation safety refresher course(s), and frequency of imaging examinations. The Mann-Whitney U test was used to assess the association between age and length of experience in the two professional groups. Multiple logistic regression analysis was conducted to study the association between the PSRSP with the other variables by using binary variables after binary categorized. The questionnaire reliability was assessed as internal consistency using Cronbach’s alpha coefficient (95% confidence interval [CI]). Statistical significance was established at \( p < 0.05 \).

Ethical considerations
This study was approved by the ethics and research committees of our institutions in Japan and Mongolia.

Results
A total of 156 questionnaires (92 radiologists, 62.4%; and 64 technicians, 37.6%) were collected and analysed (Table 1). Among these, 131 responders (84.0%) were always (more than several times a week) in direct contact with patients at work, and more than two-thirds (70.5%) of the responders had participated in radiation safety refresher courses within the last three years. The questionnaire reliability was assessed as internal consistency using Cronbach’s alpha which value was
The most commonly used PPE was a lead apron (59.6%), followed by thyroid shields (51.9%; Table 2). Only 10.3% of participants used leaded gloves, and 12.8% used leaded eyeglasses. Lead eyeglasses were used more by technicians than radiologists (20.3% vs. 7.6%, \( p = 0.027 \)); there were no significant differences in other equipment. Less than half of the responders adhered to the standard to minimize the procedures time (28.8%), and to distance themselves from the X-ray source (42.9%). There were no differences between the two professional groups.

Table 3 shows the association between participation in radiation safety refresher courses and PRSP among each professional group. For radiologists, there was a significant difference between participation in radiation safety refresher courses and the regular use of lead aprons (\( p = 0.015 \)), thyroid shields (\( p = 0.031 \)), minimized procedure time (\( p = 0.015 \)), and to distance themselves from the X-ray source (\( p = 0.025 \)). The PSRSP score ranged from 0-6 (1.39±1.479, mean±SD), and only the participation in radiation safety refresher courses was associated with a higher score in the PRSP (\( p = 0.028 \); Table 4).
Radiation safety principles in Mongolia

Table 3  Association between participation in radiation safety refreshment courses(s) and practice of radiation safety principles among each professional group

| Participation in radiation safety refreshment courses(s) | Radiologists (n=92) | Technicians (n=64) |
|---------------------------------------------------------|---------------------|--------------------|
| How often do you use the following radiation protection practices/equipment during radiological procedures? |                     |                    |
| Lead aprons                                             | Yes                 | No                 |
| Regular use                                             | 59 (64.1%)          | 33 (35.9%)         |
| Non-frequent use                                        | 41 (69.5%)          | 14 (42.4%)         |
| Thyroid shields                                         | Yes                 | No                 |
| Regular use                                             | 34 (57.6%)          | 11 (33.3%)         |
| Non-frequent use                                        | 25 (42.4%)          | 22 (66.7%)         |
| Leaded gloves                                           | Yes                 | No                 |
| Regular use                                             | 4 (6.8%)            | 3 (9.1%)           |
| Non-frequent use                                        | 56 (94.9%)          | 28 (84.8%)         |
| To minimize procedure time                              | Yes                 | No                 |
| Regular use                                             | 22 (37.3%)          | 4 (12.1%)          |
| Non-frequent use                                        | 37 (62.7%)          | 29 (87.9%)         |
| To distance from the X-ray source                       | Yes                 | No                 |
| Regular use                                             | 27 (45.8%)          | 7 (21.2%)          |
| Non-frequent use                                        | 32 (54.2%)          | 26 (78.8%)         |

Fisher’s exact test  *p<0.05

Table 4  Association Factors for Practice Score of Radiation Safety Principle (PSRSP) by Multivariate Logistic Regression Analysis

|                  | Crude OR | 95% CI | p value | Adjusted OR | 95% CI | p value |
|------------------|----------|--------|---------|-------------|--------|---------|
| Age              |          |        |         |             |        |         |
| >30 years vs ≤ 30 years (reference) | 1.244 | [0.559–2.767] | 0.592 | 1.899 | [0.705–5.120] | 0.205 |
| Sex              |          |        |         |             |        |         |
| Female vs Male (reference) | 1.253 | [0.545–2.881] | 0.595 | 0.703 | [0.294–1.677] | 0.426 |
| How long have you been employed in this occupation? |          |        |         |             |        |         |
| ≥ 6 years vs 1-5 years (reference) | 0.753 | [0.339–1.673] | 0.486 | 0.447 | [0.164–1.222] | 0.117 |
| Have you ever attended training events and/or refresher courses on radiation protection? |          |        |         |             |        |         |
| Attend vs Not attend (reference) | 3.585 | [1.180–10.898] | 0.024* | 3.618 | [1.150–11.380] | 0.028* |
| How frequent is your contact with patients undergoing imaging examinations? |          |        |         |             |        |         |
| Sometimes vs Always (reference) | 0.635 | [0.224–1.802] | 0.393 | 0.679 | [0.220–2.102] | 0.502 |

*p<0.05  Dependent variable: high (Score=3, 4, 5, 6) vs low (Score=0, 1, 2) (reference)

Discussion

In the present study, only 59.6% of the professionals regularly used lead aprons, and the usage rates of leaded gloves and eyeglasses were much lower (10.3% and 12.8%). Less than half of the responders adhered to the principle to minimize procedure time, and to distance themselves from the X-ray source. Participation in radiation safety refresher courses clearly had a positive effect on PRSP.

Evidently, the professionals in Mongolia had a tendency of not using PPE, compared to high- and lower-middle-income countries.9,10 In the United Arab Emirates, 70% of radiologists and 83% of technicians always wore lead aprons at work. Meanwhile, 50% of radiologists and 74% of technologists used a thyroid shield during interventional procedures, and 70% of both radiologists and technologists sometimes used lead gloves.9 In Egypt, 78.1% of radiographers always wore lead aprons, and 52.3% always wore thyroid shields during fluoroscopy procedures.10

In Mongolia, PPE use among professionals was clearly inadequate. According to a study in Nepal in 2012, PPE tended not to be used due to its limited availability.11 Researchers in South Africa have also reported that many radiology professionals also had unavailable PPE: they usually had lead aprons, but other types of PPE were frequently unavailable in the public sector, with a notable shortage or absence of leaded eyeglasses.12 In the present study, the frequency of using leaded eyeglasses was significantly higher in technicians than in radiologists. It was suspected that technicians may use them in preference to radiologists due to short supply. It was found that the number of PPE in radiology departments was distinctly short (for instance, only several aprons for 10 or more radiologists), old, heavy, and

—272—
difficult to use. In South Africa, leaded eyeglasses were consistently used by 10.2% of the studied cohort, and it was suspected that the low use of leaded eyeglasses was due to the lack of PPE availability.\textsuperscript{13} 

Besides the importance of PPE supplies, education and training for radiation safety for the professionals are essential. In Mongolia, according to the basic regulation on radiation protection and safety, persons who work with radiation sources must participate in a radiation safety refreshment course once every two years, and wear a personal dosimeter.\textsuperscript{14,15} The role of radiation safety refresher courses is to support personnel working near ionizing radiation by ensuring the knowledge to manage radiation risks so that work is carried out safely and in compliance with regulations, and healthcare employees and the public are protected from harmful effects.\textsuperscript{7} 

In this study, participation in radiation safety refresher courses was the positive factor of a higher PSRSP score: the professionals who participated in them acted more appropriately, compared to those who had not. A previous report from IAEA reported that the refresher courses had a significant positive impact on the radiographer’s compliance with radiation PPE usage.\textsuperscript{16} A study conducted in Iran showed that the importance of good practice as well as adequate knowledge, current policies for continuous training personnel, and intention to reduce the radiation beam dose from imaging modalities should be considered as potential factors.\textsuperscript{17} 

This study reconfirmed that both the combination of education and training regarding radiation safety and sufficient supplies of the equipment needed are essential for radiation safety of the medical professionals. Shabani \textit{et al.} reported that reduced exposure to ionizing radiation depends on several factors, such as educational level and refresher course attendance, as well as availability of accessories needed for good radiation protection.\textsuperscript{17} Le Heron \textit{et al.} also reported that education and training related to radiation protection, established working procedures, availability and use of appropriate protective tools, and an effective monitoring program were all essential elements in ensuring that medical X-ray imaging staff are adequately and acceptably protected.\textsuperscript{18} In contrast, some previous studies have shown that there were significant differences between radiation protection practice and age,\textsuperscript{18} gender,\textsuperscript{19} education,\textsuperscript{18} occupation,\textsuperscript{19} and working experience.\textsuperscript{18,20} In the present study, however, there was no significant difference according to the participants’ experience, age, gender, or frequency of imaging examination. The reason for this difference was unclear, and further studies may be necessary to clarify the significant factors affecting the appropriate acts of the professionals in the radiology department. 

This study had some limitations. First, there were a small number of participants, and it was only conducted in the city of Ulaanbaatar. Furthermore, no other professionals, such as cardiologists, dentists, or orthopedic surgeons, were included. Next, there may be a reporting bias or selective suppression of information about the participants’ behavior. However, the contents of the radiation safety refresher courses were not investigated in this study. Lastly, due to the observational nature of the study, safety awareness might have confounded both attendance rate at training events and/or refresher courses and PPE usage. Despite these limitations, this study may lay the foundation for subsequent research.

**Conclusion**

In Mongolia, many radiology professionals do not practice proper radiation protection, but participation in radiation safety refresher courses positively affected the correct measures taken by the professionals. Besides the importance of PPE supplies, further education and training on radiation safety for the professionals are required.

**Funding**

The authors have declared that no funding exists.

**Acknowledgements**

We thank all the participants and participating facilities.

**Conflict of Interest**

No conflict of interest is involved in this study.

**References**

1. Heidbuchel H, Wittkampf FH, Vano E, et al. Practical ways to reduce radiation dose for patients and staff during device implantations and electrophysiological procedures. Europace, 2014; 16: 946-964.

2. United States Nuclear Regulatory Commission. Biological effects of radiation. Reactor Concepts Manual Part 2. Ch. 9. Chattanooga, TN. United States Nuclear Regulatory Commission Technical Training Centre, 1987.

3. McLean AR, Adlen EK, Cardis E, et al. A restatement of the natural science evidence base concerning the health effects of low-level ionizing radiation. Proc Biol Sci 2017; 284: 20171070.

4. Gonchigsuren D, Munkhbaatar D, Tuvshinjargal D, et al. Development of radiology in Mongolia. World J Nucl Med 2007; 6: S77-S78.

5. The Ministry of Health, Mongolia; Center for Health Development. Health indicators. 2018. http://www.hdc.gov.mn/uploads/2019-11/2018eng.pdf

6. INTERNATIONAL ATOMIC ENERGY AGENCY, Radiation Protection and Safety in Medical Uses of Ionizing Radiation, IAEA Safety Standards Series No. SSG-46, Vienna, IAEA, 2018.

7. Cruz Suarez R, Gustafsson M, and Mrabit K. IAEA occupational radiation protection programme. Radiat Prot Dosim 2001; 96: 17-20.

8. Sylvain A, Economides S, Hardeman F, et al. Optimization of Radiation Protection: ALARA, A Practical Guidebook. Fontenay-aux-Roses, European ALARA Network, 2019.

9. Elshami W, Abuzaid M, Piersson AD, et al. Occupational dose and radiation protection practice in UAE: A retrospective cross-sectional cohort study (2002-2016). Radiat Prot Dosim 2019; 187: 426-437.

10. Abuzaid MM, Elshami W, Shawki M, et al. Assessment of
compliance to radiation safety and protection at the radiology department. Int J Radia Res 2019; 17: 439-446.

11. Bhatt CR, Widmark A, Shrestha S, et al. Occupational radiation exposure in health care facilities. Kathmandu Univ Med J (KUMJ) 2012; 10: 48-51.

12. Rose A, Uebel KE, Rae WI. Interventionalists’ perceptions on a culture of radiation protection. SA J Radiol 2018; 22: 1-10.

13. Rose A, Rae WID. Personal protective equipment availability and utilization among interventionalists. Saf Health Work 2019; 10: 166-171.

14. Law of Mongolia on Nuclear Energy, (16 July, 2009). Retrieved 3 October, 2013. https://www.legalinfo.mn/law/details/97

15. Protocol for nuclear agency commission Nuclear and radiation safety rules. (16 February, 2016). Retrieved 3 October, 2013. https://www.legalinfo.mn/annex/details/7318?lawid=11970

16. Le Heron J, Padovani R, Smith I, et al. Radiation protection of medical staff. Eur J Radiol 2010; 76: 20-23.

17. Shabani F, Hasanzadeh H, Emadi A, et al. Radiation protection knowledge, attitude, and practice (KAP) in interventional radiology. Oman Med J 2018; 33: 2: 141.

18. Ismanto S, Hassan H, Regidor D. Factors affecting compliance towards radiation protection equipment among radiographers: A cross sectional study. J Hum Phys 2019; 1: 2.

19. Abuzaid MM, Elshami W, Hasan H. Knowledge and adherence to radiation protection among healthcare workers at operation theater. Asian J Sci Res 2018; 12: 54-59.

20. Ng SE, Sa F. Assessment of awareness and practice of ionizing radiation protection procedures among exposed health care workers. Egypt J Occup Med 2020; 44: 529-544.