TURKISH JOURNAL of ONCOLOGY

Turk J Oncol 2025;40(3):207–217
doi: 10.5505/tjo.2025.4572

ORIGINAL ARTICLE

Evaluation of Acute Radiation Syndrome and Radiation Accident Dosimetry Knowledge and Awareness Levels of Turkish Radiation Oncology Professionals for Radiation Accident Emergencies, TROD 11-011 Study

Nilsu ÇİNİ,[1] Serhat ARAS,[2] Şule KARABULUT GÜL[1]

[1]Department of Radiation Oncology, Kartal Dr. Lütfi Kırdar City Hospital, İstanbul-*Türkiye*
[2]Department of Radiation Oncology, Haydarpaşa Numune Training and Research Hospital, İstanbul-*Türkiye*

OBJECTIVE

In advanced healthcare institutions, radiation oncology professionals are among the priority teams whose knowledge and experience are utilized in radiation accident emergencies. The team with high knowledge and awareness in first aid and damage assessment, plays a critical role in the effective management of vital interventions and resources.We aimed to evaluate the awareness and knowledge levels of radiation oncology professionals, Radiation Oncology Physician (ROP)and Radiation Oncology Medical Physicist (ROMP), regarding radiation accident emergencies.

METHODS

The study was designed to analyze responses of radiation oncology professionals working in Türkiye. The 1st part of the survey consists of 4 questions aiming to collect demographic information. The 2nd part consists of 13 questions aiming to measure the knowledge levels about acute radiation syndrome (ARS) and radiation accident dosimetry (RAD). SPSS27.0 was used in the analyses, the significance difference between the groups was examined using the Chi-Square independence test, $p<0.05$.

RESULTS

Of the participants, 51.1%were ROP, 48.9%were ROMP. Analysis of the 2nd part, 6 questions (2-ARS/4-RAD) were determined to have a correct response rate ≥50%. Only one RAD question has a "no idea" response rate ≥50%. Incorrect response rate ≥50% was observed in 3questions (2-ARS/1-RAD). The correct response rates among occupational groups, ROPs had a significantly higher response rate in 4-ARS questions,while ROMPs had a significantly higher rate in1-ARS/3-RAD questions ($p<0.05$), and no significance was found between occupational groups in 5 questions ($p>0.05$).

CONCLUSION

The survey revealed variability in the level of knowledge regarding different features of ARS and RAD. Also observed that correct response rates varied among professional groups. The results emphasize the importance of standardizing the knowledge of all professionals. It is recommended training on clinical management of ARS and RAD, and to organize comprehensive and periodic training programs. Especially simulation-based training and case studies can make significant contributions.

Keywords: Acute radiation syndrome; radiation accident dosimetry; radiation accident emergencies; radiation oncology professionals.

This survey study was presented as an oral presentation at the 1st Bilsel International Semerkant Scientific Research Congress, and only the abstract was published in the congress booklet.

Also this survey study was presented as an poster presentation at the 25th National Radiation Oncology Congress, and only the abstract was published in the congress booklet.

Received: May 08, 2025
Revised: June 18, 2025
Accepted: July 31, 2025
Online: September 03, 2025

Accessible online at:
www.onkder.org

PhD. Nilsu ÇİNİ
Kartal Dr. Lütfi Kırdar Şehir Hastanesi,
Radyasyon Onkolojisi Kliniği,
İstanbul-Türkiye
E-mail: nilsucini@gmail.com

Turk J Oncol 2025;40(3):207–217
doi: 10.5505/tjo.2025.4572

INTRODUCTION

In addition to the radiation sources naturally found in our environment, radiation emitted from artificial radioactive sources has been integrated into many areas of our lives through developing technology.[1] The amount of ionizing radiation originating from medical applications constitutes the vast majority of the radiation dose emitted from artificial sources to which the general population is exposed.[2]

Even if radiation protection precautions are taken, radiation emergencies may occur caused by artificial radiation sources during medical procedures or in other ways. Alongside the radiation exposure of the Japanese population due to atomic bombs (1945, Japan), the Radiation Emergency Response Center/Training Site Radiation Accident Records reported 420 nuclear incidents between 1944 and 2011, the most important of which are Goiânia (1985, Brazil), Chernobyl (1986, Ukraine), and Fukushima (2011, Japan).[3]

A radiation accident could be defined as an incident involving an unplanned or unforeseen radiation emission, misuse of radiation devices, or misapplication or mislay of radioactive substances. During a radiation accident, it is possible to be exposed to various types of radiation and different magnitudes of radiation dose.

Ionizing radiation has early and late-term adverse side effects on living organisms, which can vary depending on the amount of dose and duration of exposure.[4,5] Acute radiation syndrome (ARS) is a high-risk, low-frequency diagnosis that can be fatal and is difficult to diagnose without a history of significant ionizing radiation exposure.[6] Acute radiation syndrome is a group of dose-dependent signs and symptoms that occur after short-term exposure to high levels of ionizing radiation.[7,8] The first multinational and multidisciplinary guideline for ARS, specifically for radiation-related emergencies, was published in 1997 by the European Commission, called MEDICAL TREATMENT PROTOCOLs for Radiation Accident Victims (METREPOL).[9]

Classically, it has been stated that for ARS to develop, whole body or partial body exposure must be at least 1.0 Gy, and ARS is not expected for exposures below 0.5 Gy.[9] Due to its dose-dependent effects, ARS has been divided into four different subsyndromes named after the system affected at each dose threshold: Hematopoietic (≥1.0 Gy), cutaneous (≥3.0 Gy), gastrointestinal (≥6.0 Gy), and neurovascular (≥8.0 Gy).[10,11]

In the hematopoietic subsyndrome, ionizing radiation damages radiosensitive lymphocytes and stem cells in the bone marrow, causing pancytopenia and predisposing the patient to opportunistic infections.[7,10–12] Clinically, monitoring the decline in absolute lymphocyte count (ALC) is the most practical method of assessing radiation dose after exposure. A 50% decrease in ALC within the first 24 hours after exposure followed by a more severe decrease within 48 hours indicates a potentially lethal exposure in the range of 5.0–10.0 Gy radiation dose. The post-exposure lymphocyte nadir typically occurs 8–30 days.[13,14]

In the cutaneous subsyndrome, ionizing radiation can cause epilation, erythema, scaling, and even radionecrosis because the skin contains differentiated and rapidly dividing cells, like those in the bone marrow and gastrointestinal tract.[7,10,15,16] Following exposure to doses of ≥3.0 Gy, the cutaneous syndrome manifests itself and overlaps with other sub-syndromes.

In the gastrointestinal (GI) subsyndrome, damage in the intestine track can cause a wide range of problems, including bleeding, electrolyte abnormalities, and infection.[10] This subsyndrome usually develops within 5 days after exposure. Radiation Dose <1.5 Gy: Prodromal symptoms: Nausea and vomiting. Radiation Dose >5.0 Gy: Destruction of intestinal crypt cells and loss of mucosal barrier. Death is related to dehydration, electrolyte imbalances, bacterial translocation, GI wall necrosis and subsequent perforation.[13,17]

Neurovascular sub-syndrome is associated with brain edema along with loss of consciousness, fever and hypotension, among other findings.[10] When the radiation exposure dose is >10.0 Gy, localized changes in the cerebrovascular system include: Impaired capillary circulation, damage to the blood-brain barrier, acute inflammation of the meninges, petechial hemorrhages. Patients may present with headache, nausea, altered mental status or seizures. [13,18]

Regardless of subsyndromes, ARS progresses through four stages: Prodromal, latent, overt disease, and recovery/death. The higher the dose, the faster the patient progresses through these stages. Prodromal Stage: Begins 0–2 days after exposure, Latent Stage: Begins 2–20 days after exposure, Overt Disease: Begins 21–60 days after exposure.[10]

Unfortunately, historically, ARS has been diagnosed late in its course.[19] The METREPOL guideline has determined the first step of treatment as taking a good anamnesis regarding the type, duration and dose of exposure, removing external contamination and fluid-electrolyte replacement. Individuals exposed to a dose of 2.0–3.0 Gy should be isolated due to the risk of infection.[20] Early symptoms that manifest themselves in the prodromal phase include nausea, vomiting, anorexia, apathy, diarrhea, fever, headache, and tachycardia. If these symptoms begin within approximately 2 hours, the guideline states that the patient is most likely exposed to a dose exceeding 2.0–4.0 Gy, and if they begin within minutes, to doses exceeding 10 Gy.[13]

It is critical that first responders be able to diagnose and provide initial treatment for patients presenting with ARS. This critical requirement makes it essential to identify competent and educated professionals of healthcare institutions, keep relevant training up to date, and increase their awareness. In advanced healthcare institutions, the contributions of radiation oncology professionals, as well as emergency physicians, to the first response team in radiation accidents or emergencies have been recognized. First of all, radiotherapy is a practice that develops errors or near misses as termed 'incidents', or accidents, despite the precautions taken during the use of highradiation doses and complex treatment process. Managing these rare events makes radiation oncology professionals who may encounter them daily, prepared to respond and evaluate radiation accidents quickly compared to many other teams.

Since radiation oncologists are the physicians most thoroughly trained to understand and manage the effects of radiation exposure on healthy and malignant cells, the American Society for Radiation Oncology (ASTRO) noticed it would be proper for its members to be one of the primary resources in responding to radiation accidents and disasters.[21] In this context, ASTRO initiated the creation of a training document working with the American College of Radiology (ACR) and the American Association of Physicists in Medicine (AAPM) for radiation oncology and radiology professionals. Disaster Preparedness for Radiology Professionals booklet is designed to summarize information on preparing for a radiation accident or emergency, managing contaminated individuals, to collecting data on possible exposure dose assessment and radiation exposure on health.[22] Also, the International Atomic Energy Agency (IAEA) has emphasised that one of the primary responsibilities of radiation oncology physicians (ROP) is to assess medically any radiation accident or incident.[23]

On the other hand, the IAEA published a document for the medical physicists, the partner professionals of radiation oncology, called Guidance for Medical Physicists Responding to a Nuclear or Radiological Emergency. As mentioned, clinical medical physicists working in hospitals have in-depth knowledge of high energy radiation dosimetry, dose reconstruction and dose measurement techniques and tools. They constitute a unique group of professionals who, with the proper training, can provide effective support for the triage of radiation accidents, emergency preparedness and response activities. Using this reservoir of radiation protection experts in emergency and preparedness teams is good medical practice.[24]

Determination or close estimation of patient radiation exposure dose is crucial for the accident response team to decide on urgent interventions and protective protocols. The most important parameter to be learned during anamnesis is the time until the onset of vomiting, and also determining the absolute lymphocyte decline rate and chromosomal aberration status is vital for the design of prophylactic and prospective treatments.

In particular, the time from exposure to the onset of vomiting and the absolute lymphocyte decline rate are guides for the dose of exposure and the corresponding intervention. Marx et al.[25] reported that vomiting that started within 1 hour after exposure was generally associated with more than 6.5 Gy of dose exposure, and vomiting that started between 1–4 hours was associated with approximately 3.5 Gy of dose exposure. Determination of chromosomal aberrations can be done within 24 hours and after an incubation time, information is reached within 48–72 hours, and even if it is not effective in the emergency management of the patient, it is necessary for later.[25,26]

One of the most important factors in the management of this entire process is the calculation and reconstruction of the accident dose. In this context, the IAEA has created a series of training documents and focused on radiation dosimetry in radiation emergencies.[27] It is possible to estimate the exposure dose and develop a rapid intervention scheme based on the ARS symptoms observed in the victims, but this process should be supported by the actual calculation results of post-accident dosimetry. In order to define a long-term treatment scheme, it is vital to determine the dose absorbed in the tissues of individuals with high accuracy.[28]

If it is an accident that occurs in a radiation area, field monitors or personal dosimeters that are already at the scene can be used, but it should not be forgotten that in dose exposures above a certain range, these equipments can also overdose and become inadequate or show a value (saturation) lower than the actual dose. If the accident is in another location than the hospital, the whole body measurements of individuals who come to the emergency room should be recorded with provided portable survey meters.

Turk J Oncol 2025;40(3):207–217
doi: 10.5505/tjo.2025.4572

However, in radiation emergencies that develop following a radiation accident that involves a higher dose or a radiation type other than the one designed to be measured, or in areas where there is no dosimetric equipment or field monitor retrospective dosimetric techniques are needed for radiaiton accident dose reconstruction. For this purpose, medical physicists start the process by collecting various materials to be used in radiation accident dosimetry (RAD).

Retrospective techniques are divided into two groups as Physical or Biological techniques. Physical techniques involve the analysis of collected samples using physical methods. Retrospective Physical dosimetry techniques can be performed with a range of materials such as glass, alanine, sugar, plastic, silicates and tobacco.[29] Electron paramagnetic resonance (EPR), Thermoluminescence (TL) and Optically stimulated luminescence (OSL) are typical physical dosimetry techniques.

Retrospective biodosimetry is based on various cytogenetic analyses that can mostly detect radiation-induced DNA damage and incorrect repair. Blood circulates throughout the body, so data from blood samples are reported as an average of the radiation dose received from all parts of the body, therefore some blood samples should be collected several days or weeks after exposure to allow for complete circulation. Biolgicasl materials to be used in biological dosimetry are whole blood, lymphocytes, blood plasma/serum. Dicentric Chromosome Test (DCA), Premature Chromosome Condensation (PCC), Cytokinesis-block Micronucleus (CBMN) Cytome Assay, Translocation Analysis by FISH, The γ H 2 AX Assayand EmergingAssay: Omics are the main tests.[27]

Retrospective dose reconstruction, assessment and management of ARS are vital and necessary in radiation accident emergencies. Therefore, it is critical that the first response team consists of professionals who are qualified these processes. Radiaiton oncology professionals have a major responsibility in the planning and assignment of that workflow. This survey study highlights the well planned updated education is a need for radiation accident emergency for the radiation oncololgy profesionals.

The main purpose of the study is to determine the knowledge levels of radiation oncology professionals, ROP and radiation oncology medical physicists (ROMP), about ARS and RAD in radiation accident emergencies through the questions in the survey.

The second aim of the study is to stimulate the awareness and the need for these informantions of radiation oncology professionals about ARS and RAD in radiation accident emergencies through the questions in the survey and to pioneer awareness development and the organization of necessary training based on the results.

This survey is a rare study conducted to determine the requirements and the levels of awareness in this area. In addition, the ROP and ROMP groups evaluated together as radiation oncology professionals. Planning trainings due to the determined issues will increase the effectiveness of Turkish radiation oncology professionals in case of a radiation accident emergencies.

MATERIALS AND METHODS

Ethical approval has been received from the scientific research ethics committee of Kartal Dr. Lütfi Kırdar City Hospital. (No: 20241010.9919126, Date: 25/10/2024.) The study is conducted according to the Helsinki Declaration.

The study was designed to apply a questionnaire survey intended by our team to professionals, ROP and ROMP working in radiation oncology clinics in Turkey between 11.11.2024 and 24.12.2024 and to analyze the answers collected. The questions were multiple choice and were designed for one correct answer. The survey was distributed as an online form and data was collected online. Individuals participated with their own consent.

The questionnaire survey was divided into two parts. The first part consists of four questions aimed at collecting demographic information about the participants. The posed questions were: Gender, Age Range (years old), Professional Experience in the field (years), and Title in the Professional field.

The second part consists of 13 questions aiming to measure the knowledge levels of ARS (7) and basicRAD (6). See the posed multiple-choice questions and the topic they related to in Appendix 1.

In the analyses of the collected answers, percentages of answers were calculated and the significance difference between the groups was examined with the Chi-Square independence test by using SPSS 27.0, and $p<0.05$ was determined for statistical significance.

RESULTS

The survey was shared on the online platform of the Turkish Radiation Oncology Association and the Turkish Medical Physics Association. It is estimated that the survey reached 794 Radiation Oncology Physicians and 429 Radiation Oncology Medical Physics Specialists, a total of 188 people responded. Of these 188 people, 96

Table 1 Demographic characteristic distribution of the survey participants

	n	%
Gender		
Female	92	48.9
Male	96	51.1
Age range		
21–30	36	19.1
31–40	78	41.5
41–50	58	30.9
51–60	14	7.4
>61	2	1.1
Professional experience in the field		
1–5 years	66	35.1
6–15 years	62	33.0
16–25 years	52	27.7
26–35 years	8	4.3
>36 years	–	–
Professional title		
Radiation oncology physician	96	51.1
Radiation oncology medical physicist	92	48.9

(51.1%) are Radiation Oncology Physicians, the response rate was 12.1% and 92 (48.9%) are Radiation Oncology Medical Physicist, the response rate was 21.4%. Ninety-six, 51.1% of the participants were male and 92, 48.9% were female. No participants with >36 years of professional experience period in the field who responded to the survey. A fairly homogeneous group was reached in terms of professional expertise. See the analysis of demographic characteristics of the participants in Table 1.

According to the analysis of the second part answers, 6 questions (2-ARS and 4-RAD) were determined to have a correct answer rate above 50%. Only one RAD question (Question 12: Which is not one of the Retrospective accident dosimetry techniques?) received a "no opinion" answer rate of over 50%. Three questions (2-ARS and 1-RAD) were observed with an incorrect answer rate above 50%. See the percentages of correct answers / "no opinion" answers and their distribution among the questions in Table 2. There are a total of 13 questions in the second section and more than 50% of correct answers were observed in 6 questions. This result underlines that the knowledge levels are halfway to being sufficient.

Correct answer rates were examined among professional groups via Chi-square independence test. Analysis revealed that; ROP had a significantly higher correct answer rate in 4 questions (4-ARS), while ROMP had a significantly higher correct answer rate in 4 questions (1-ARS and 3-RAD) ($p<0.05$ significance). No significant difference was found between professional groups in 5 questions (2-ARS and 3-RAD) ($p>0.05$). See the distribution of the significant difference between different professional groups for correct answers in Table 3. The 5 questions that did not make a difference in the correct answers in both professional groups indicate a significant gap for knowledge about ARS and RAD for radiation accident emergencies.

Table 2 Correct, Incorrect and "No opinion" answer percentages for the acute radiation syndrome (ARS) and radiation accident dosimetry (RAD) questions

Question	Correct answer (%)	Incorrect answer (%)	"No opinion" (%)
No:1 RAD	67.0	30.9	2.1
No:2 ARS	42.6	43.6	13.8
No:3 ARS	34.0	26.6	39.4
No:4 ARS	42.6	19.1	38.3
No:5 ARS	74.5	17.0	8.5
No:6 ARS	27.7	51.1	21.3
No:7 ARS	27.7	50.0	22.3
No:8 ARS	51.1	41.5	7.4
No:9 RAD	58.5	36.2	5.3
No:10 RAD	57.4	31.9	10.6
No:11 RAD	63.8	20.2	16.0
No:12 RAD	36.2	10.6	53.2
No:13 RAD	18.1	55.3	26.6

Table 3 Analysis of correct answers and statistical significance differences between professional groups

Question	Correct answer analysis: Significant difference between professional groups	In favour of the professional group
No:1 RAD	p=0.000	ROMP
No:2 ARS	p=0.001	ROMP
No:3 ARS	p=0.011	ROP
No:4 ARS	p=0.004	ROP
No:5 ARS	p=0.093	NS
No:6 ARS	p=0.070	NS
No:7 ARS	p=0.021	ROP
No:8 ARS	p=0.014	ROP
No:9 RAD	p=0.068	NS
No:10 RAD	p=0.023	ROMP
No:11 RAD	p=0.333	NS
No:12 RAD	p=0.001	ROMP
No:13 RAD	p=0.213	NS

$p<0.05$ for statistical significance. RAD: Radiation accident dosimetry; ARS: Acute radiation syndrome; ROMP: Radiation oncology medical physicists; ROP: Radiation oncology physician; NS: Not significant

Turk J Oncol 2025;40(3):207–217
doi: 10.5505/tjo.2025.4572

Table 4 Analysis of correct answers and statistical significance differences between different professional experience periods in the field

Question	Correct answer analysis: Significant difference between different professional experience periods in the field	In favour of the professional experience period in the feld
No:1 RAD	p=0.246	NS
No:2 ARS	p=0.002	6–15 years
No:3 ARS	p=0.040	1–5 years
No:4 ARS	p=0.003	16–25 years
No:5 ARS	p=0.023	6–15 years
No:6 ARS	p=0.000	6–15 years
No:7 ARS	p=0.000	6–15 years
No:8 ARS	p=0.024	16–25 years
No:9 RAD	p=0.004	16–25 years
No:10 RAD	p=0.000	6–15 years
No:11 RAD	p=0.110	NS
No:12 RAD	p=0.000	6–15 years
No:13 RAD	p=0.581	NS

p<0.05 for statistical significance. RAD: Radiation accident dosimetry; ARS: Acute radiation syndrome; NS: Not significant

Also, correct answer rates were examined among different groups of professional experience periods in the field via the Chi-square independence test. Analysis revealed that; 1–5 years had a significantly higher correct answer rate in 1 questions (1-ARS), 6–15 yearshad a significantly higher correct answer rate in 6 questions (4-ARS and 2-RAD), 16–25 yearshad a significantly higher correct answer rate in 3 questions (2-ARS and 1-RAD), (p<0.05 significance). No significant difference was found between different groups of professional experience periods in the field in 3 questions (3-RAD) (p>0.05). See the distribution of the significant difference between different professional experience periods in the field for correct answers in Table 4. The difference between periods of professional experience once again underline the need for standardization of knowledge about ARS and RAD for radiation accident emergencies.

DISCUSSION

Radiation is used in many areas of diagnosis and treatment in the medical field. Radiation oncology, unlike the other disciplines, uses a higher energy range radiation and the application of radiation therapy continues uninterrupted for a period of time. Thus, radiation oncology professionals manage the dosimetric verification requirements necessary for the application of this high-energy radiation, and the biologic side effects that develop during or after the treatment. Radiation oncology is a complex, multi-profession dynamic modality of cancer treatment. There are multiple steps with many handovers of work and many opportunities for patient safety to be compromised. Radiation accidents, incidents or near-miss events may occur during radiation therapy to which patients or staff are exposed.[30]

Even though radiation oncology professionals are always well prepared for a radiation accident or incident caused by its very complicated application process, there is a possibility. Many reported events were analyzed and the work precaution charts were developed based on these real events and served to be used in the clinical routine to reduce accident/incident rate. Safety in Radiation Oncology (SAFRON) is a reporting and learning system on radiotherapy and radionuclide therapy incidents and near misses.[31]

Despite the precautions and developed systems, an analysis of a study has shown that while technological and process enhancements can reduce certain error pathways, others can be created.[32] Therefore, it is important to always be prepared, up to date and follow up. Bose et al.[33] presented an automated incident triage and severity determination pipeline that can predict high and low severity incidentsin the radiation oncology.

Many other reported accidents or events show how well-prepared radiation oncology professionals are for radiation accident emergencies. On the other hand, IAEA, AAPM and ASTRO underlined their importance as a responder source for the health system. For definitive assessment and long-term treatment decisions, it is essential that, ROP, ROMPs and other professionals employ a multidisciplinary approach to provide medical support, dose estimations, an updated registry of individuals, medical follow-up and psychological support.[34]

Professionals involved in the response team like emergency medical physicians, nurses, and paramedics will need information on estimations of the exposed dose by patients, so physicians may decide on and implement appropriate treatments. Also, guidance information may be requested from ROPs, especially about ARS management. Other than they will need reassurance if it is safe to work with possibly contaminated patients. And it is may expected that the responder team will be concerned about their own radiation protection. In this case, ROMPs will need to advise on effective methods of handling contaminated or irradiated patients (or waste) while keeping their personal dose and contamination levels as low as possible.[34]

The medical community will be an important partner in the population monitoring process after a radiation accident. The proper use of common hospital radiation instrumentation, such as gamma cameras and thyroid probes, for screening potentially contaminated individuals will be one of the important things to be organized. The local medical health/radiation physicist will obviously play a key role in any such utilization of hospital resources.[35]

The medical management of individuals involved in a nuclear or radiological emergency requires specially trained personnel. Lessons learned from previous events have demonstrated that caring for these individuals calls for a multidisciplinary team of healthcare professionals if the response is to be effective.

Our study reached a homogeneous participant group of ROPs and ROMPs professionals.The survey results revealed variations in the percentage of correct answers, particularly for questions measuring knowledge levels about the different stages, symptoms, and radiation threshold doses of ARS. Likewise in the analysis of the questions regarding the RAD topic, variations in the percentage of correct answers were observed. In addition, the analyses revealed that correct answer rates varied among professional groups 8 of 13 questions, significanlty.

Analyses demonstrated that correct answer rates varied among different groups of professional experience periods in the field. This situation emphasizes the importance of standardizing the knowledge levels on general radiation emergencies that may be vital for critical intervention processes and closing the knowledge gaps of all professionals on the determined subjects. In this context, it is recommended to enrich the training on clinical management of ARS and practical instructions about RAD.

As a result of such surveys, missing information is identified and current and repeated training programs are prepared by the teams' associations or institutions to eliminate these deficiencies. Especially with the radiation accident scenarios to be prepared based on artificial intelligence, different situations will be handled in various ways, analysis methods will be mastered and workflow protocols will be designed.

Our study is the first survey study in this field to evaluate radiation oncology professionals' ROPs and ROMPs together in radiation accident emergencies. Arrangement of comprehensive and periodic training programs will be an effective method for updating the knowledge levels of professionals. Especially simulation-based training and case studies can make significant contributions to increasing awareness and application skills in critical intervention processes. If we consider the limitations of our survey study, the number of questions/content could be worked on and the number of professionals reached could be increased.

CONCLUSION

Radiation oncology professionals working with high-energy radiation, have the capacity to guide rapid adaptation and medical intervention plans to such high-dose radiation accident emergencies. Therefore, an increased and optimised level of knowledge and awareness of radiation oncology professionals will be vital for the effective use of resources in a radiation accident emergency.

At this point, it is important to determine the current status of the knowledge of this professional team. With this survey study for the first time in the literature, we evaluated the knowledge of radiation oncology professionals in radiation accident emergencies, and we also underlined the issues that need to be updated and standardized within this important subject. What is planned for the future could be the determination of the effectiveness of the designed particular and repeated artificial intelligence-based training and case examples that will prepare the team for a radiation accident event.

Ethics Committee Approval: The study was approved by the Kartal Dr. Lütfi Kırdar City Hospital Ethics Committee (no: 20241010.9919126, date: 25/10/2024).

Informed Consent: Informed consent was obtained from all participants.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

Funding: The author(s) did not received any financial support for the research, authorship, and/or publication of this article.

Use of AI for Writing Assistance: No AI technologies utilized.

Author Contributions: Concept – N.Ç., S.A., Ş.K.G.; Design – N.Ç., S.A.; Supervision – Ş.K.G.; Funding – N.Ç.; Materials – N.Ç.; Data collection and/or processing – N.Ç.; Data analysis and/or interpretation – N.Ç.; Literature search – N.Ç.; Writing – N.Ç.; Critical review – N.Ç., S.A., Ş.K.G.

Peer-review: Externally peer-reviewed.

Turk J Oncol 2025;40(3):207–217
doi: 10.5505/tjo.2025.4572

REFERENCES

1. International Atomic Energy Agency. Radiation in everyday life. Available at: https://www.iaea.org/Publications/Factsheets/English/radlife. Accessed Aug 27, 2025.
2. Paolicchi F, Miniati F, Bastiani L, Faggioni L, Ciaramella A, Creonti I, et al. Assessment of radiation protection awareness and knowledge about radiological examination doses among Italian radiographers. Insights Imaging 2016;7(2):233–42.
3. Karacabey S. Radyasyon: güncel bir bela. Available at: https://acilci.net/radyasyon-guncel-bir-bela/. Accessed Aug 27, 2025.
4. Brenner DJ, Doll R, Goodhead DT, Hall EJ, Land CE, Little JB, et al. Cancer risks attributable to low doses of ionizing radiation: Assessing what we really know. Proc Natl Acad Sci U S A 2003;100(24):13761–6.
5. Arslanoğlu A, Bilgin S, Kubal Z, Ceyhan MN, Ilhan MN, Maral I. Doctors' and intern doctors' knowledge about patients' ionizing radiation exposure doses during common radiological examinations. Diagn Interv Radiol 2007;13(2):53–5.
6. Ebeling M, Bloom A, Boggiano MM, Peterson DT, Peterson T. Employing high-fidelity simulation for the high-risk, low-frequency diagnosis and management of acute radiation syndrome. MedEdPORTAL 2023;19:11331.
7. Christensen DM, Iddins CJ, Sugarman SL. Ionizing radiation injuries and illnesses. Emerg Med Clin North Am 2014;32(1):245–65.
8. Centers for Disease Control and Prevention. A brochure for physicians: Acute radiation syndrome. Available at: https://stacks.cdc.gov/view/cdc/50897/cdc_50897_DS1.pdf. Accessed Aug 27, 2025.
9. İslam MM. Akut radyasyon sendromu. Available at: https://acilci.net/akut-radyasyon-sendromu/. Accessed Aug 27, 2025.
10. Oak Ridge Institute for Science and Education. The medical aspects of radiation incidents. Available at: https://orise.orau.gov/reacts/index.html. Accessed Aug 27, 2025.
11. Dainiak N, Waselenko JK, Armitage JO, MacVittie TJ, Farese AM. The hematologist and radiation casualties. Hematology 2003;2003(1):473–96.
12. Christensen DM, Iddins CJ, Parrillo SJ, Glassman ES, Goans RE. Management of ionizing radiation injuries and illnesses, part 4: Acute radiation syndrome. J Osteopath Med. 2014;114(9):702–11.
13. López M, Martín M. Medical management of the acute radiation syndrome. Rep Pract Oncol Radiother 2011;16(4):138–46.
14. Goans RE, Holloway EC, Berger ME, Ricks RC. Early dose assessment in criticality accidents. Health Phys 2001;81(4):446–9.
15. Iddins CJ, Christensen DM, Parrillo SJ, Glassman ES, Goans RE. Management of ionizing radiation injuries and illnesses, part 5: Local radiation injury. J Osteopath Med 2014;114(11):840–8.
16. Iddins CJ, DiCarlo AL, Ervin MD, Herrera-Reyes E, Goans RE. Cutaneous and local radiation injuries. J Radiol Prot 2022;42(1):011001.
17. Lombardini ED, Pacheco-Thompson ME, Melanson MA. Radiation and other physical agents. In Haschek W, Rousseaux C, eds. Haschek and Rousseaux's Handbook of Toxicologic Pathology. Elsevier, p. 1421–503.
18. Radiation Injury Treatment Network. RITN acute radiation syndrome treatment guidelines. Available at: https://ritn.net/-/media/project/nmdp/ritn/documents/treatment/ritn-acute-radiation-syndrome-treatment-guidelines-2020-october.pdf. Accessed Aug 27, 2025.
19. Koenig KL, Goans RE, Hatchett RJ, Mettler FA, Schumacher TA, Noji EK, et al. Medical treatment of radiological casualties: Current concepts. Ann Emerg Med 2005;45(6):643–52.
20. Fliedner TM, Friesecke I, Beyrer K. Medical management of radiation accidents: Management of the acute radiation syndrome. Available at: https://oparu.uni-ulm.de/server/api/core/bitstreams/fdda72b2-e0ba-41ad-a398-2e836206d34f/content. Accessed Aug 27, 2025.
21. American Society for Radiation Oncology. ASTRO's role in radiation disaster management. Available at: https://www.astro.org/practice-support/quality-and-safety/disaster-management. Accessed Aug 27, 2025.
22. American Society for Radiation Oncology. Disaster preparedness for radiology professionals. Available at: https://www.astro.org/getmedia/81a9bbf4-d9fe-43d6-92a7-9e1f61613810/prepbroch.pdf. Accessed Aug 27, 2025.
23. International Atomic Energy Agency. Responsibilities of health professionals. Available at: https://www.iaea.org/resources/rpop/health-professionals/radiotherapy/responsibilities-of-health-professionals. Accessed Aug 27, 2025.
24. International Atomic Energy Agency. Guidance for medical physicists responding to a nuclear or radiological emergency. Vienna: International Atomic Energy Agency; 2020.
25. Marx J, Hockberger R, Walls R. Rosen's emergency medicine: Concepts and clinical practice. 8th ed. Philadelphia: Elsevier; 2014.
26. Sakamoto-Hojo ET. Lessons from the accident with 137Cesium in Goiania, Brazil: contributions to biological dosimetry in case of human exposure to ionizing radiation. Mutat Res Toxicol Environ Mutagen 2018;836:72–7.

27. International Atomic Energy Agency. Assessment of occupational exposure due to external radiation sources. Available at: https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1076_web.pdf. Accessed . Accessed Aug 27, 2025.
28. Barazzuol L, Coppes RP, van Luijk P. Prevention and treatment of radiotherapy-induced side effects. Mol Oncol 2020;14(7):1538–54. Available at: https://febs.onlinelibrary.wiley.com/doi/10.1002/1878-0261.12750. Accessed Aug 27, 2025.
29. Maltar-Strmečki N, Bortolin E, Kenzhina L, Patrono C, Testa A. Editorial: Developing novel materials and new techniques of biological and physical retrospective dosimetry for affected individuals in radiological and nuclear emergencies. Front Public Health 2022;10:1117269.
30. Arnold A, Ward I, Gandhidasan S. Incident review in radiation oncology. J Med Imaging Radiat Oncol 2022;66(2):291–8.
31. Zarei M, Gershan V, Holmberg O. Safety in radiation oncology (SAFRON): Learning about incident causes and safety barriers in external beam radiotherapy. Phys Med 2023;111:102618.
32. Bissonnette JP, Medlam G. Trend analysis of radiation therapy incidents over seven years. Radiother Oncol 2010;96(1):139–44.
33. Bose P, Sleeman WC, Syed K, Hagan M, Palta J, Kapoor R, et al. Deep neural network models to automate incident triage in the radiation oncology incident learning system. In Proceedings of the 12th ACM international conference on bioinformatics, computational biology, and health informatics. New York: ACM; 2021. p. 1–10.
34. International Atomic Energy Agency. Medical management of persons internally contaminated with radionuclides in a nuclear or radiological emergency [Internet]. Vienna: International Atomic Energy Agency; 2018.
35. Miller CW, Whitcomb RC, Ansari A, McCurley C, Guinn A, Tucker F. The roles of medical health physicists in a medical radiation emergency. Health Phys 2007;93(5 Suppl):S187–90.

Turk J Oncol 2025;40(3):207–217
doi: 10.5505/tjo.2025.4572

Appendix 1 Survey questions and distribution of questions related to topics of the acute radiation syndrome (ARS) and the radiation accident dosimetry (RAD)

Survey questions	Related topic
1. What is the maximum annual permissible dose limit for members of the public, as recommended by the International Commission on Radiological Protection (ICRP)? • 0.1 mSv • 0.5 mSv • 1 mSv • 2 mSv • No opinion	RAD
2. What is the threshold radiation exposure dose of the whole/partial body to develop acute radiation syndrome (ARS)? • 2 Gy • 0.5 Gy • 1 Gy • 0.01 Gy • No opinion	ARS
3. Which of the following matches between ARS sub-syndrome and radiation exposure dose is incorrect? • Cutaneous ≥3 Gy • Hematopoietik ≥1 Gy • Gastrointestinal ≥6 Gy • Genitouriner ≥12 Gy • Neurovascular ≥8 Gy • No opinion	ARS
4. Which of the following matches between ARS phases and observation times after radiation exposure is incorrect? • Prodromal phase - Next 0-2 days • Latent Phase - Next 2-20 days • Pre-immune phase-Next 0-20 days • Disease Phase - Next 21-60 days • No opinion	ARS
5. Which of the following is not a symptom of the prodromal phase of ARS? • Nausea, vomiting • Anorexia, apathy • Diarrhea • Multiple organ failure • Headache • No opinion	ARS
6. The time to onset of vomiting and the rate of decline in Absolute Lymphocyte Count (ALC) determine the possible exposed radiation dose and intervention plan. What is the minimum radiation dose (Gy) for vomiting that begins within 2 hours? • 1 Gy • 2 Gy and above • 4 Gy and above • 6 Gy and above • No opinion	ARS
7. How many hours after a radiation accident can chromosomal aberrations be detected? • 12-24 hours • 24-48 hours • 48-72 hours • No opinion	ARS

Appendix 1 Cont.

Survey questions	Related topic
8. What is the most critical time period following radiation exposure for the management of ARS? • First 24 hours • First 48 hours • First 36 hours • Between the first 24 - 48 hours • No opinion	ARS
9. Which of the following is not one of the four factors that can help determine radiation exposure severity in a patient who develops ARS? • Radiation dose • Distance from radiation source • The presence of shielding during radiation exposure • Direction of the radiation exposure • Medical treatment possibilities and transportation speed • No opinion	RAD
10. Which of the following is not a way of radiation exposure in a patient with ARS? • External radiation exposure • Taking radioactive substances into the body by eating, inhaling or wound • External contamination • Environmental contamination • No opinion	RAD
11. Which of the following is not one of the tools that can be used to obtain exposure dose information after a radiation accident? • Field monitors • Personal dosimeters • Retrospective dosimetric techniques • Ion chambers • No opinion	RAD
12. Which of the following is not one of the retrospective accident dosimetry techniques? • Electron paramagnetic resonance • Dysentic chromosome test (DCA) • Thermoluminescence (TL) or optical warned luminescence (OSL) • Relative ion chamber measurements • Cytokinesis-blok micronucleus (CBMN) sitom test • No opinion	RAD
13. Which of the following is not one of the material used in retrospective accident dosimetry? • Dental or nail • Cotton or cellulose • Skin epithelium or mucosal epithelium • Blood or lymphocyte • Resistances or inductors • No opinion	RAD