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Research Article

The Place, Importance and Development Approaches of Radiation Safety and Protection Education in Associate Degree Health Programs

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Abstract: Radiation has become an indispensable tool in the diagnosis and treatment processes of modern medicine. Especially radiological imaging and radiotherapy applications increase the quality and accuracy of health services. However, the potential biological effects of ionizing radiation pose significant risks to both patients and health workers. Therefore, radiation safety and protection issues should be an integral part of the professional competencies of health workers. Associate degree health workers who undertake a significant part of health services—such as radiology technicians, dental health technicians, and nuclear medicine technicians—are among the groups that may be directly exposed to radiation. It is vital that these groups receive adequate radiation safety training during the preparation process for the profession. In this compilation study, the place, importance, and needs for development of radiation safety and protection training in associate degree health programs were evaluated with a holistic approach. The content analysis of education curricula, comparison with international standards, educator competencies, the role of practical training, and the current situation were analyzed and suggestions for improvement were presented through certification systems. In this context, the study aims to provide contributions that will guide health education policies.

Keywords: Radiation safety, Associate degree education, Radiation protection

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1. Introduction

The increasing use of technology in healthcare has led to the widespread use of ionizing radiation, especially in imaging and treatment processes. Radiological diagnostic tools, nuclear medicine applications, and procedures such as radiotherapy are of great importance for the early diagnosis and effective treatment of diseases [1]. However, since the biological effects of radiation can lead to serious consequences, the safe use of these technologies is of vital importance.

Associate degree health education plays a critical role in preparing technicians and technicians, who constitute a large part of the healthcare sector, for the profession. In this context, equipping personnel working with radiation with professional knowledge and skills is of great importance for the health safety of individuals and society [2]. Radiation safety education is a fundamental area of education for employees to protect both their own health and ensure patient safety.

However, studies show that radiation safety education in associate degree health programs in Türkiye is not sufficiently structured and that theoretical knowledge is not supported by practical application in many programs [3]. This deficiency both creates weaknesses in the professional competence of employees and endangers patient safety. In this review article, the use of radiation in the health field and its potential effects will be discussed, and the current status of radiation safety education at the associate degree level and areas that need to be developed

will be evaluated. At the same time, comparative analyses with international education standards will be made and examples of good practices in education will be presented. Thus, it is aimed to develop constructive suggestions for health education policies.

2. Use and Effects of Radiation in Healthcare

Ionizing radiation is used as an important tool in diagnosis and treatment processes, but its uncontrolled or incorrect use can cause serious health problems. Most medical imaging methods (x-ray, CT, mammography, etc.) are based on ionizing radiation and therefore pose an exposure risk for both the patient and the healthcare professional [4].
The biological effects of radiation occur in the form of DNA damage at the cellular level. If this damage is not repaired, it can cause cell death, mutations and, in the long term, cancer [5]. Occupational exposure is usually low-dose, long-term accumulation and poses a serious occupational risk, especially for healthcare professionals at the associate degree level.
Studies show that radiology technicians and nuclear medicine technicians are constantly exposed to low-level radiation throughout their professional lives and that their health risks increase when protective measures are not adequately implemented [6]. In this context, it is necessary to raise awareness of individuals about the effects of radiation and to provide a safety culture during the education process.

3. The Concept of Radiation Safety and Basic Principles

Radiation safety covers scientific and administrative practices developed to prevent harm to individuals, society and the environment in the use of ionizing radiation. These practices are structured in line with certain principles to minimize radiation exposure and provide effective protection. The basis of radiation safety is based on the ALARA (As Low As Reasonably Achievable) principle, which expresses the idea that the dose should be kept at the lowest possible level [7].
The ALARA principle includes not only physical protection but also administrative measures such as proper planning of work processes, working with trained personnel and regular inspections. This principle plays a critical role in the daily practices of technicians and technicians, especially those working in the health sector. The ALARA approach is shaped around three basic physical principles: time, distance and protection [8]:
Time: Reducing the contact time with the radiation source reduces exposure.
Distance: Moving away from the radiation source reduces the dose inversely proportional to the exposure.
Protection: Physical barriers such as lead aprons, goggles, and barriers prevent radiation from reaching the body.

In addition, regular use of personal dosimeters is of great importance in terms of monitoring and evaluating the total dose to which personnel are exposed. Especially for health technicians who will graduate from associate degree programs, internalizing these principles will ensure that safe working habits are established in their professional lives [9].
Radiation safety is also a legal and ethical responsibility. The International Atomic Energy Agency (IAEA) states that countries should establish national regulations to ensure safety in radiation applications [10]. In Turkey, these regulations are carried out through various legislations such as the Turkish Atomic Energy Authority (TAEK) and the Radioactive Substance Use and Safety Regulation.
However, research in the field of education shows that theoretical knowledge on these principles is conveyed in many associate degree programs, but practical training is limited [11]. This situation increases the risk of incomplete knowledge and incorrect application in post-graduate work environments.
As a result, radiation safety training should not be limited to the transfer of information only, but should be supported by practical training to ensure that these basic principles are transformed into behavior. The systematic inclusion of these principles in the training curriculum is indispensable for the establishment of an individual and institutional safety culture.

4. Basic Content of Radiation Safety and Protection Training

Radiation safety and protection training is of vital importance for health technicians to consciously fulfill their professional responsibilities. The main purpose of this training is to ensure that health workers are informed about the risks of ionizing radiation, gain the ability to apply safety measures, and internalize the safety culture [12].
The training content should cover both theoretical and practical knowledge and skills. Within the scope of theoretical training; topics such as physical properties of radiation, biological effects, dosimetry, protection methods, legal regulations, and emergency procedures are covered [13]. Practical training should be conducted in practical areas such as the use of personal protective equipment, dosimeter monitoring, safe operation of devices and patient positioning.
The following modules are widely used in structuring radiation safety training:
a) Radiation Physics and Dosimetry: Basic physical concepts, measurement of radiation and dose calculations.
b) Biological Effects: The effects of radiation at the cellular level, short-term and long-term health consequences.
c) Protection Methods: Time, distance and protection principles, use of personal protective equipment.
d) Legal and Ethical Regulations: Radiation safety regulations in Turkey and internationally.
e) Emergency Management: Protocols to be followed in cases of radiation leakage and contamination.

The teaching methods used in the education process also play a major role in the effective transfer of content. Traditional lectures, case studies, laboratory applications, simulation techniques and e-learning platforms provide diversity in education [14]. In particular, simulation-supported applications provide students with experience through real-life scenarios and support permanent learning.
Evaluation methods should be prepared to measure the theoretical knowledge and practical competence of students. Multiple choice exams, applied skills exams (OSCE), case study assignments and project studies are effective tools in this context.
Research shows that the knowledge level and awareness of students who receive radiation safety training increases significantly [15]. However, to maintain the effectiveness of the training, periodic updates, trainer training and continuous professional development opportunities should be provided.

5. Current Situation in Associate Degree Health Programs in Turkey

The structure and scope of radiation safety education in associate degree health programs in Turkey vary depending on the type of program and educational institution. Programs such as radiology, nuclear medicine, dental prosthesis technology, and anesthesia train technical personnel who may be directly exposed to radiation. In these programs, radiation safety education is usually included in the course curriculum under the title of “Radiation Safety” or “Principles of Working with Radiation”; in some programs, these topics are covered in a limited way in the content of relevant vocational courses [16].
Although the framework curricula published by the Council of Higher Education (YÖK) determine some standards, the extent to which these standards are met in practice varies among institutions. While detailed training supported by modern simulation laboratories is provided in some foundation universities, theoretical education is provided with limited equipment and faculty members in many state universities [17].
Studies on students' knowledge levels on radiation safety show that there are significant knowledge gaps. For example, in a study conducted by Tekin et al. (2020), it was determined that 60% of associate degree students did not have sufficient knowledge about dosimeter use, protective equipment, and the ALARA principle [18]. This situation clearly reveals the lack of standardization in education.
In addition, the expertise levels of faculty members in radiation safety also affect the quality of education. Instructors need to have access to professional development opportunities in this field and be equipped with constantly updated information.
All this data shows that radiation safety education provided at the associate degree level in Turkey needs to be improved in terms of both content and practice. In order to increase the quality of education, a national level curriculum standardization should be provided, infrastructure investments supporting practical education should be made, and trainer training should be encouraged.

6. International Approaches and Comparisons

Radiation safety education is accepted as an important part of the professional competencies of healthcare personnel worldwide. Standards determined by international organizations guide the education systems of countries and contribute to the dissemination of good practice examples. The educational practices in Türkiye's associate degree health programs should also be evaluated within this framework, and deficiencies should be identified by comparing them with international norms [19].
In the United States, the educational curricula of radiology technicians are shaped according to the guidelines determined by the American Society of Radiologic Technologists (ASRT). This curriculum requires students to be provided with theoretical and practical radiation safety training [20]. In addition, at the end of the training, students take the American Registry of Radiologic Technologists (ARRT) exam and receive national certification. The certification process measures the level of knowledge on radiation safety and maintains professional standards.
On the other hand, European Union countries organize their national curricula in line with the EURATOM guidelines of the European Commission. EURATOM Directive 2013/59 requires all personnel working with radiation to receive appropriate training. In this context, vocational training programs in many European countries are supported by continuing education modules based on practical applications [21].
In countries such as Australia and Canada, radiation safety training adopts a comprehensive approach that includes not only healthcare professionals but also educators. Educational institutions are audited through accreditation processes and national safety protocols for radiation are standardized in training [22].

Compared to Turkey, radiation safety education is provided in a more systematic, applied and continuous format in many countries. In Turkey, the curricula in this field are largely based on theoretical knowledge, and there are deficiencies in the application and evaluation processes [11]. In addition, the lack of a national certification system makes it difficult to measure and monitor the level of knowledge after graduation.
International approaches can also guide associate degree programs in Turkey. Determining common standards in education, increasing practical training and expanding professional qualification exams will ensure the training of qualified healthcare personnel closer to international norms.

7. Consequences and Risks of Lack of Education

Deficiencies in radiation safety education not only increase individual health risks, but also negatively affect the quality of social security and healthcare services. Inadequately trained healthcare technicians can increase the risk of exposure to ionizing radiation for both themselves and their patients. In addition, this situation brings with it the legal and ethical responsibilities of hospital managements [23].
One of the most common deficiencies is that the trainings are theoretical and practical skills are not sufficiently acquired. When simulation, laboratory studies and real clinical environment practices are limited, students cannot reach the level of sufficient preparation in the work environment after graduation. This may result in behaviors such as incorrect positioning, not using protective equipment or neglecting the dosimeter [24].
In addition, the up-to-dateness of the materials and resources used in the training is also very important. Since radiation safety is a dynamic and scientifically open field, trainings with old and outdated content may lead to insufficient knowledge. Another serious problem is that trainers do not have sufficient equipment in this field [25].

The consequences of inadequate radiation safety training include:
• Increase in occupational diseases (e.g. cataracts, thyroid diseases),
• Long-term health problems in patients exposed to radiation,
• Failure of institutional audits and penal sanctions,
• Ethical violations and compromised patient safety.
In addition, psychosocial effects should not be ignored. The uncertainty and fear brought about by working with radiation increases with lack of training; this negatively affects employee motivation and job satisfaction [26].
It is also supported by recent studies that inadequate training causes safety violations encountered by health technicians in the field. In the study conducted by Soyal and Ortabağ (2023), it was reported that operating room technicians had low levels of knowledge about ionizing radiation and inadequate use of personal protective equipment [27]. These findings reveal that the practical aspect of training should be strengthened.

Therefore, training deficiencies are not only an academic problem, but also a public health and occupational safety problem. Unless the quality of education programs is improved, the opportunities provided by technological developments cannot be used effectively.

8. Recommendations for Radiation Safety Education

A multidimensional approach is required to make radiation safety education more effective, sustainable and compliant with standards in associate degree health programs. Improvements in both curriculum content and education methods will both increase the professional competence of healthcare professionals and strengthen patient safety.

a) Curriculum Standardization: A mandatory "Radiation Safety and Protection" course should be created in all associate degree health programs in Turkey where there is a risk of radiation exposure, and the content of this course should be linked to national standards determined by the Council of Higher Education. This content should include practical modules as well as theoretical information [17].

b) Increasing Applied Education Opportunities: Students should be prepared for situations they may encounter in the field with tools such as simulation laboratories, virtual reality applications and clinical rotations. Radiation measurement devices, dosimeter usage, and practices related to personal protective equipment must be integrated into the curriculum [14].

c) Competence and Continuous Development of Trainers: It is important that the instructors who teach the courses are experts in this field. Working with certified trainers in the field of radiation safety should be encouraged; continuous professional development training should also be organized for trainers [25].

d) Development of a National Certification System: Just like in the ARRT (USA) or EURATOM (EU) systems, a radiation safety certification program to be conducted before or after graduation

e) E-learning and Distance Education Modules: Online education platforms should be established using the opportunities provided by technology, and the accessibility of education should be increased. In this way, students at different universities can receive the same quality education and resource inequality can be reduced [19].

f) Post-graduation Monitoring and Education: Radiation safety education should be continued not only during school years but also throughout professional life. Information can be updated with in-service trainings to be organized at least once a year in health institutions.

g) Multidisciplinary Cooperation: Radiation safety concerns not only radiology technicians, but also nuclear medicine, anesthesia, physical therapy and many other fields. Therefore, education should be designed with a multidisciplinary approach and should cover different health programs.

The above recommendations will not only increase safety at the individual level; they will also make great contributions in terms of fulfilling institutional responsibility, improving the quality of health services and protecting patient rights.

9. Conclusion

Radiation safety and protection education is one of the basic elements that directly affects the quality and safety of health services. Since health technicians, especially those receiving associate degree education, are in direct contact with radiation in their professional lives, it is of great importance that their education in this regard is complete, up-to-date and practice-based.

In this study, the basic characteristics of radiation, its effects on health and protection methods were discussed, and the necessity of radiation safety education in associate degree health programs was examined in detail. Current practices in Turkey were evaluated, compared with international examples and suggestions were presented for the development of the system.

The following conclusions were reached in line with the findings obtained:

• Radiation safety education in Turkey has not yet been sufficiently standardized and is far from being practice-based.

• Students' knowledge levels are insufficient and they are likely to encounter risky practices after graduation.

• International practices are more advanced than Turkey in terms of certification in education, applied learning and trainer competence.
• Restructuring the education system is essential for patient safety and employee health.
As a result, radiation safety education should be considered not only as a course but as an integral part of health education. Improvements in this area will positively affect not only individual skill levels but also the entirety of health services. Acting with institutional responsibility awareness and increasing academic collaborations in this regard are of great importance for the development of the system.

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