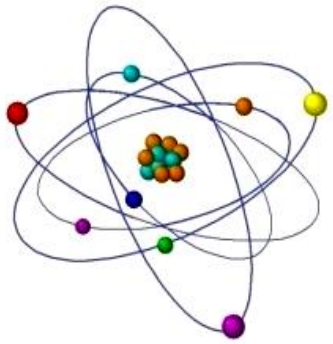
PROBLEMS OF RADIATION PROTECTION OF RADIOLOGISTS IN PRIMARY HEALTH CARE



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ABSTRACT: *Background. Radiologists play a crucial role in modern healthcare by ensuring timely diagnosis of a wide range of diseases. Despite significant advances in diagnostic imaging technologies and the implementation of modern radiation protection measures, occupational exposure to ionizing radiation remains a major professional hazard. This issue is particularly relevant in primary healthcare institutions, where limited financial resources, high workloads, and insufficient opportunities for equipment modernization are common. Objective: To analyze current scientific evidence regarding occupational radiation exposure among radiologists working in primary healthcare settings, identify major risk factors, and evaluate existing approaches to radiation safety management for medical personnel. Materials and Methods: A literature review of publications indexed in the PubMed/MEDLINE database from January 2020 to June 2025 was conducted. The search strategy included the following keywords: occupational radiation exposure, radiation protection, radiology personnel, radiologists, occupational health, medical radiation workers, occupational dosimetry, and radiation safety. Systematic reviews, meta-analyses, original research articles, and recommendations issued by international organizations concerning radiation safety of healthcare personnel were included in the analysis. Results: The literature review demonstrated that the implementation of digital imaging technologies, modern personal protective equipment, and occupational dosimetry systems contributes to a reduction in occupational radiation exposure among healthcare workers. Nevertheless, occupational radiation exposure remains a significant concern, particularly in primary healthcare facilities. The main risk factors include the use of aging equipment, insufficient dosimetric monitoring, limited opportunities for staff training, and inadequate compliance with radiation protection principles. Conclusions: Improving radiation safety among radiologists requires a comprehensive approach that includes equipment modernization, regular dosimetric monitoring, continuous professional education, and strict adherence to the ALARA principle.*

Keywords: radiation safety, occupational radiation exposure, occupational dosimetry,

INTRODUCTION

Diagnostic imaging occupies a leading position in modern medicine, providing timely disease detection, monitoring of pathological processes, and assessment of treatment effectiveness. Over recent decades, there has been a steady increase in the number of diagnostic procedures involving ionizing radiation, including conventional radiography, computed tomography, mammography, and interventional procedures. According to the World Health Organization (WHO) and the International Atomic Energy Agency (IAEA), medical use of ionizing radiation represents the largest artificial source of radiation exposure to the population, highlighting the need to ensure a high level of radiation safety for both patients and healthcare workers. The professional activity of radiologists is associated with exposure to several occupational hazards, among which chronic low-dose ionizing radiation remains the most significant. Despite substantial progress in digital imaging technologies, automated exposure control systems, and personal protective equipment, occupational radiation exposure continues to be a relevant concern. Long-term accumulation of radiation doses may increase the risk of stochastic effects, including malignancies, radiation-induced lens opacities, and other adverse health outcomes among medical personnel. Radiation safety issues are particularly important in primary healthcare institutions. This level of healthcare delivery is often characterized by limited financial resources, prolonged use of aging equipment, insufficient opportunities for technological modernization, and shortages of qualified personnel. These factors may negatively affect the effectiveness of radiation protection programs and compliance with safety regulations. Current international recommendations are based on the ALARA (As Low As Reasonably Achievable) principle, which requires occupational exposure levels to be maintained as low as reasonably achievable while considering social and economic factors. Implementation of this principle includes the use of personal protective equipment, regular dosimetric monitoring, equipment maintenance, optimization of work organization, and continuous professional education of healthcare workers. Given the continuing relevance of this issue, ensuring radiation safety among radiologists remains one of the priorities of occupational health programs in healthcare systems. Analysis of contemporary scientific evidence allows assessment of existing occupational risks and identification of the most effective preventive strategies in primary healthcare settings. The aim of this review was to analyze current scientific evidence regarding occupational radiation exposure among radiologists working in primary healthcare institutions and to evaluate major risk factors and contemporary approaches to radiation safety management.

MATERIALS AND METHODS

A literature review of publications indexed in the PubMed/MEDLINE database from January 2020 to June 2025 was performed. The literature search was conducted using the following keywords and their combinations: occupational radiation exposure; radiation protection;

radiology personnel; radiologists; occupational health; medical radiation workers. The review included systematic reviews, meta-analyses, original studies, and recommendations issued by international organizations regarding radiation safety of healthcare personnel. In addition, documents published by the International Commission on Radiological Protection (ICRP), International Atomic Energy Agency (IAEA), World Health Organization (WHO), and European Society of Radiology (ESR) were analyzed. Publications focusing exclusively on patient radiation doses, veterinary radiology, dental radiology, and studies without full-text availability were excluded. Following evaluation of titles, abstracts, and full-text articles, studies containing data on occupational radiation exposure, dose accumulation risk factors, and radiation protection measures were selected for further analysis.

RESULTS

The search of the PubMed/MEDLINE database identified studies addressing occupational radiation exposure among radiology personnel, radiation protection methods, and the organization of safe working conditions. The literature analysis demonstrated a consistent decline in average occupational radiation doses over recent years due to the widespread implementation of digital imaging technologies, automated exposure control systems, and improved personal protective equipment [1–4]. According to most studies, occupational dose levels depend on the type of imaging procedures performed, technical characteristics of equipment, personnel training, and compliance with radiation safety regulations [2,4,5]. The highest exposure levels are reported among personnel involved in interventional diagnostic and therapeutic procedures [2,3]. However, continuous dosimetric monitoring remains necessary even during routine radiographic and computed tomography examinations [4]. Modern digital radiography systems have been shown to reduce both patient radiation doses and scattered radiation exposure affecting healthcare personnel [1,4]. Nevertheless, aging equipment remains in use in many primary healthcare facilities, potentially limiting the effectiveness of radiation protection measures. All reviewed studies emphasized the importance of adherence to the ALARA principle, aimed at maintaining radiation exposure at the lowest reasonably achievable level [1,2,6]. The most effective radiation protection strategies include minimizing exposure time, maximizing distance from the radiation source, and utilizing shielding devices [6,7]. Considerable attention has been devoted to personal protective equipment. The use of lead aprons, thyroid shields, protective eyewear, and mobile lead barriers significantly reduces occupational radiation exposure [2,3,7]. However, several studies reported inadequate compliance with protective equipment use, particularly under conditions of increased workload [5]. Another important area of research concerns individual dosimetric monitoring. Electronic personal dosimeters have been shown to improve occupational exposure monitoring and facilitate timely identification of potentially hazardous situations [4,5]. Primary healthcare facilities continue to face challenges such as limited financial resources, insufficient equipment modernization, and restricted opportunities for regular radiation safety training. These factors may reduce the effectiveness of existing radiation protection programs. Overall, current

technologies enable substantial reductions in occupational radiation exposure; however, radiation safety in primary healthcare settings remains an important issue requiring further improvement of organizational and technical protection measures [8–11].

DISCUSSION

The reviewed literature indicates substantial progress in occupational radiation safety over recent years. The development of digital radiography systems, automated exposure control technologies, and improved personal protective equipment has contributed to a reduction in occupational radiation doses compared with previous decades. Nevertheless, complete elimination of radiation-related risks remains impossible, necessitating continuous improvement of personnel protection systems. Particular attention should be paid to radiation safety management in primary healthcare institutions. Unlike large tertiary hospitals and university medical centers, outpatient facilities often operate under financial constraints, which may delay equipment replacement and limit investments in radiation monitoring programs. Consequently, personnel protection depends not only on equipment characteristics but also on organizational factors, Compliance with the ALARA principle remains one of the most important determinants of occupational safety. The reviewed studies indicate that a substantial proportion of occupational exposure may result from inadequate adherence to basic radiation protection practices, even when modern equipment is available. This finding underscores the importance of continuous education and the development of a strong safety culture within healthcare organizations. Individual dosimetric monitoring also plays a critical role. Recent publications demonstrate that electronic dosimeters improve radiation exposure surveillance and enable prompt identification of potentially hazardous situations. In primary healthcare settings, such technologies may represent an effective tool for enhancing radiation safety. The effectiveness of radiation protection measures depends not only on technical infrastructure but also on personnel competence. Studies indicate that regular radiation safety training contributes to lower occupational doses and improves compliance with personal protective equipment use. Promising approaches to further improving radiation safety include modernization of imaging equipment, implementation of low-dose technologies, expansion of continuous professional education programs, development of remote dosimetric monitoring systems, and strengthening internal radiation safety audits. Despite considerable achievements in reducing occupational radiation exposure, radiation protection of radiologists in primary healthcare settings remains a highly relevant issue. Effective solutions require a combination of technical, organizational, and educational measures aimed at minimizing occupational risks and improving workplace safety.

CONCLUSIONS

The analysis of publications indexed in PubMed/MEDLINE between 2020 and 2025 demonstrated that occupational radiation exposure remains one of the major risk factors in radiologists' professional activity. Although radiation doses have significantly decreased owing

to advances in digital technologies and radiation protection measures, ensuring personnel safety remains a priority, particularly in primary healthcare institutions. The most important strategies for improving radiation safety include modernization of radiological equipment, regular individual dosimetric monitoring, strict adherence to the ALARA principle, use of modern personal protective equipment, and continuous professional education of healthcare workers. Comprehensive implementation of these measures contributes to reducing occupational radiation exposure and improving workplace safety among radiology professionals.

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