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REVIEW

Management of psychological impacts of radiation safety protocols on nursing staff in radiotherapy departments

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ABSTRACT

Objective: Ionizing radiation, which is utilized in radiation therapy, is one of the mainstays of cancer treatment. It is used to eliminate cancer cells while causing the least possible harm to surrounding healthy tissues. Exposure to ionizing radiation poses significant hazards to healthcare workers, including nursing staff in radiotherapy departments. In order to reduce risks and safeguard both patients and employees, radiation safety procedures such as the use of protective equipment, shielding, and monitoring must be implemented. Despite these safeguards, psychological issues such as stress, anxiety, and burnout are common among nursing staff.

Methods: A systematic review was conducted to explore the psychological impacts of radiation safety protocols on nursing staff. PRISMA guidelines were followed, with a literature search across Google Scholar, PubMed, and Web of Science from 2000 to 2024. Studies included impacts on mental health such as anxiety, stress, and burnout. Data extraction focused on psychological impacts, safety measures, and coping strategies.

Results: Out of the 602 initial records, 58 studies met the inclusion criteria, highlighting common psychological challenges such as stress, anxiety, and exhaustion associated with radiation safety protocols. Both short-term and long-term exposure to radiation significantly contribute to heightened anxiety levels. Furthermore, organizational culture and the quality of staff training serve as critical determinants of psychological well-being.

Conclusion: Nursing staff in radiotherapy are concerned about the psychological strain brought on by radiation safety procedures. Institutions should consider mental health support to build a resilient workforce in radiotherapy departments. Modern safety technologies, organizational support, and appropriate training are essential for reducing anxiety and enhancing the well-being of staff.

Keywords: radiation safety procedures, psychological effects, stress, anxiety, radiation treatment, nursing staff

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INTRODUCTION

High-energy radiation to target and eliminate malignant cells while conserving healthy tissue as much as possible is the principle of radiation therapy, which plays a notable role in cancer treatment (1). Radiation therapy treatments are frequently applied as a single treatment in a curative manner or in co-occurrence with surgery and chemotherapy to improve treatment outcomes and patient survival rates (2). Besides being beneficial as a treatment technique, exposure to ionizing radiation instigates intrinsic danger to the healthcare workforce specifically dealing with patients.

Nursing staff of radiotherapy departments are engaged in versatile roles in patient surveillance, treatment delivery, and assuring the straightforward operation of therapeutic approaches. Patient evaluation and instructions during complex treatment plans under radiation oncologists are accounted for by nurses, who also rely on certain radiation safety protocols to protect patients and personnel from ionizing radiation (3) (4).

Efficacious radiation safety protocols are crucial in radiotherapy departments, as personal protective equipment (PPE), proper shielding, adherence to safety guidelines, and consistent radiation level monitoring are utilized to achieve effective radiation safety (5). Mitigation of prospective long-term health risks correlated with cumulative radiation exposure can cause the development of malignancies and further unfavorable health repercussions (6).

METHOD

The psychological impacts of safety protocols related to occupational radiation exposure on the nursing workforce in radiotherapy departments are appraised in this systematic review. Publications from 2000 to 2024 in Google Scholar, PubMed, and Web of Science were used to conduct the search using keywords such as "nursing staff," "radiation safety," "psychological impact," and "radiotherapy departments," with related terms. The PRISMA guidelines were also followed to ensure a comprehensive assessment of the literature.

Peer-reviewed English-language studies with a specific focus on nursing employees in radiotherapy departments that have been published between 2000 and 2024 were included in the review. These studies investigated the ways in which radiation security measures influenced psychological outcomes consisting of anxiety, stress, burnout, or fear. Review papers were included in addition to original research (qualitative, quantitative, or mixed methods). Studies that neglected psychological consequences, were not peer-reviewed, did not have full-text availability, or concentrated on other healthcare providers were excluded. Two researchers performed the study process of selection independently to minimize bias. In accordance with the PRISMA flow diagram, abstracts and titles were screened first, and then full-text assessment was conducted using the inclusion and exclusion criteria (Figure 1).

A standardized form was utilized to extract data from each study, such as information about the author, year, country, design, sample size, psychological consequences, radiation precautions, and coping strategies. This procedure ensured that each significant variable for analysis was explained in great detail. Since study designs and results varied widely, the data synthesis was performed narratively. Common psychological issues, such as increased stress and anxiety from exposure to radiation and exhaustion from long-term risks, were identified through thematic analysis, in addition to coping strategies such as training, peer support, and organizational tactics. No new data collection or ethical approval was required because the review investigated previously published studies. However, each investigation was evaluated for compliance with ethical guidelines, including acquiring adequate consent from those who participated. The exclusion of non-English studies, possible publication bias due to the review's reliance on previously published research, and the inability to perform a meta-analysis caused by disparities in study designs and conclusions were some of its limitations.

RESULTS

The database search turned up 602 records in total, which included 305 from PubMed, 154 from Google Scholar, and 143 from ScienceDirect. Following a

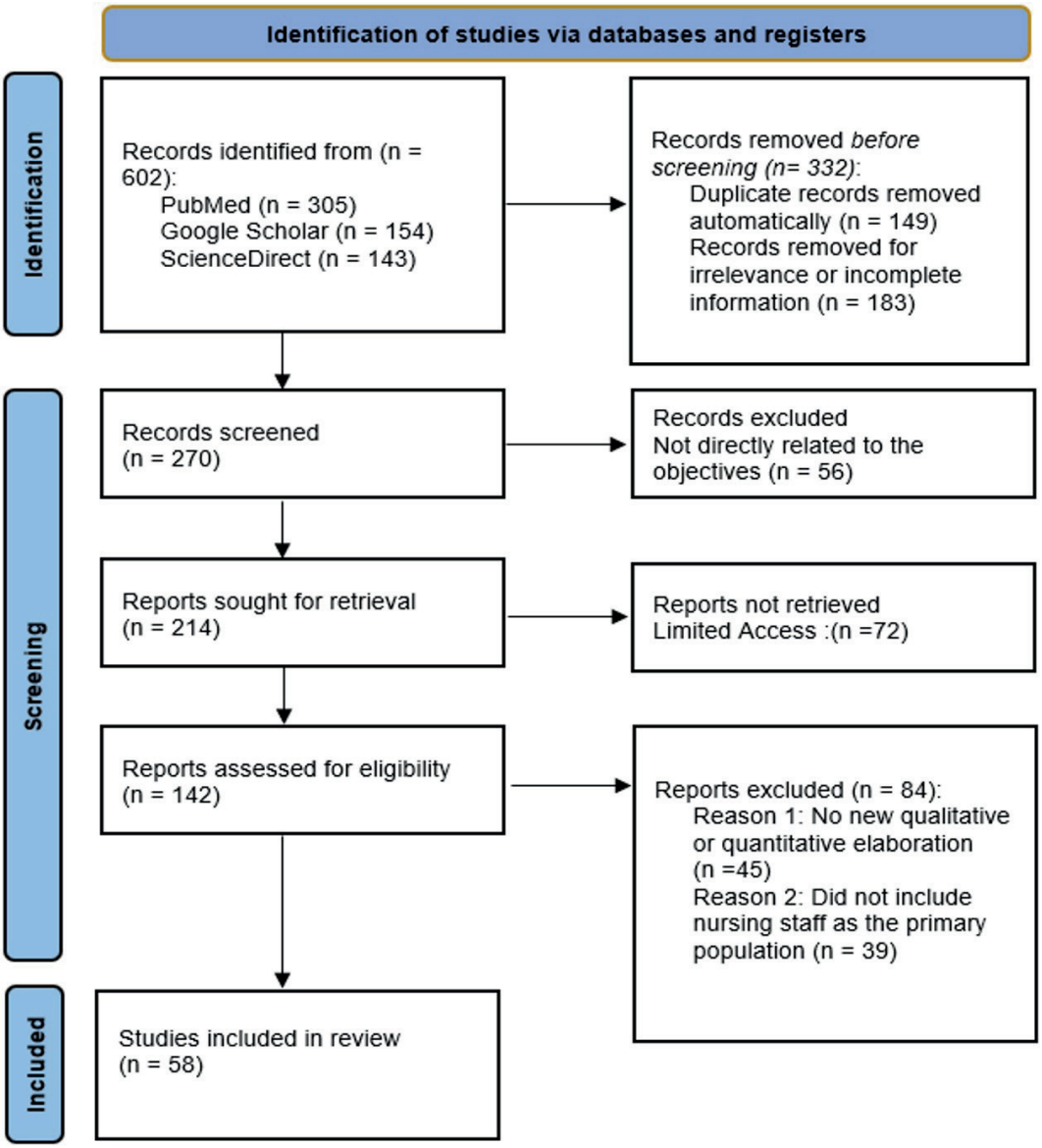

Figure 1. PRISMA 2020 flow diagram.

preliminary assessment, 332 records were eliminated: 183 were considered to be irrelevant, and 149 duplicates were removed with automation tools. Two hundred seventy studies remained for further assessment. Fifty-six records were eliminated during the preliminary screening, allowing 214 reports for full-text assessment. However, 72 reports were unable to be obtained due to access restrictions, leaving 142 studies for assessment. Eighty-four of these were disqualified for a variety of reasons: 39 were not focused on nursing staff, and 45 offered no novel perspectives on the psychological effects of radiation security protocols. In summary, 58 studies were evaluated, offering instructive insights into the mental health problems—such as anxiety, stress, burnout, and mechanisms for coping—of nursing professionals in radiotherapy.

Psychological challenges faced by nursing staff

Radiation safety protocols in radiotherapy departments are essential to ensure the protection of both patients

and staff; nevertheless, nursing staff have to work closely with radiation-emitting equipment and sources, and these protocols cause significant psychological impacts on patients as well (7). Even when stringent safety measures are in place, constant adjacency to radiation sources can lead to heightened stress and anxiety (8). Research has shown that elevated stress during procedures involving radiation has been frequently reported by nurses, with concerns provoked by the potential for accidental exposure (9). This stress stems not only from immediate risks but also from the long-term effects of radiation exposure, even within regulatory constraints. Insomnia, irritability, and hypervigilance can be caused by persistent stress, impacting both professional performance and personal well-being (10).

Although safety limits have been assured, worries about the cumulative effects of radiation exposure persist, and nursing staff in radiotherapy experience a great deal of mental strain due to the fear of long-term health effects (11). Long-term exposure to ionizing radiation has been associated with a number of health hazards, including genetic mutations and cancer, justifying this fear (12). Chronic stress and anxiety due to the uncertainty surrounding potential long-term effects have an impact on their overall quality of life and job satisfaction (13).

The cumulative effects of anxiety, stress, concerns about risks to long-term health, compassion fatigue, and burnout can have a substantial impact on the emotional and physical well-being of nursing professionals in radiotherapy (14). Nurses often experience emotional depersonalization and fatigue due to the continual attention to detail required to comply with safety procedures (15). In addition, the psychological implications of this strain can impact lifestyle contentment and interpersonal interactions outside of the work environment (16).

In radiotherapy departments, organizational culture has an important effect on whether these psychological effects are mitigated or worsened. Stress levels can be substantially reduced in supportive work environments that place a high priority on employee training, offer adequate radiation safety resources, and promote open discussion (17). On the other hand, an absence of organizational support or a perceived neglect for the well-being of employees may exacerbate feelings of isolation and anxiety among nurses (18).

Factors influencing psychological impact

For the purpose of delivering therapeutic doses to cancerous tissues while limiting exposure to healthy cells, radiation therapy involves the use of ionizing radiation, such as photons (X-rays) and particles (protons and electrons) (19). Safety profiles for different kinds of radiation vary significantly, which has consequences for healthcare providers' occupational safety along with patient outcomes. Since it allows for deep tissue penetration, photon-based therapies are frequently employed; and they require careful monitoring and shielding to avoid unintentional exposure (20). Particle therapies, such as proton therapy, offer accurate targeting but necessitate rigorous adherence to safety protocols to prevent operational mistakes and minimize the effects on employees (21).

Workload pressures, institutional safety culture, equipment reliability, and the sophisticated nature of safety protocols are among the numerous variables that influence adherence. These procedures present specific challenges for oncology nursing staff in radiotherapy departments, which may influence their stress levels and mental health (22). Procedural compliance and psychological resilience in radiation treatment settings are emphasized by the fact that noncompliance, whether as a consequence of human error or equipment malfunctions, may increase anxiety and lower confidence (23).

An abundance of support systems and tools have been established to assist nurses in radiotherapy departments in managing occupational stress caused by the emotional burden that their position places on them. These systems and tools, which comprise both internal and external aid, include peer support, counselling, radiation safety training, and alterations that reduce physical strain (24). Additionally, comprehensive support frameworks might assist radiotherapy departments in establishing healthier workplaces through improved psychological resilience and job satisfaction (25).

Coping mechanisms and support strategies

Radiation safety education and training are necessary to mitigate the psychological impact on nursing staff in radiation therapy departments. Those who obtain thorough and continuous instructions become more capable of understanding radiation risks and carrying out security measures (26).

Nurses' anxiety and fears about potential hazards can be mitigated by well-designed training programs while simultaneously improving their confidence when performing radiation-related duties. Nurses also feel more empowered and in charge of their work environment when they have become familiar with safety regulations and radiation protection strategies. Maintaining higher awareness reduces the psychological impact of working in a high-risk environment, and this encourages adherence to procedures (27). Ongoing education, which keeps nurses up to date on the recent advancements in radiation safety, improves their competence and adaptability which are required for maintaining vigilance and guaranteeing adherence to the evolving safety regulations (28). Frequent training, psychological support programs and counselling services strengthen nurses' ability to manage the anxiety and stress of their profession, resulting in advantages when dealing with the overall emotional strain caused by their profession (29)(30).

Research has shown that access to counselling services allows nurses to process their feelings in a secure atmosphere (31). Nurses can mitigate emotional distress and exhaustion by addressing issues related to radiation exposure and exploring coping mechanisms. Moreover, counselling helps individuals develop adaptive coping strategies and resilience, which enable them to better handle stress at work (32). Nursing staff members also feel more united and supported when they engage in psychological support programs designed specifically for healthcare professionals (33). Nurses can share their experiences, coping mechanisms, and encouragement with one another in peer support groups and debriefing sessions (34). These initiatives help create a welcoming environment where nurses in radiotherapy feel appreciated, understood, and less isolated. Establishing resilient environments for nursing staff necessitates strong team dynamics as well as assistance from fellow employees and superiors. A supportive environment where nurses feel valued and respected is established by cooperative teamwork and positive interpersonal relationships (35). Cohesive team dynamics have been shown to reduce the psychological effects of radiation safety procedures. Effective teamwork and open communication allow fellow employees to share duties, assist one another through difficulties, and offer emotional support, which enhances job satisfaction and lowers anxiety and isolation among nursing staff (36).

In addition, supportive supervision is necessary for encouraging nurses' well-being and growth as professionals. Compassionate supervisors who concentrate on staff welfare, offer constructive feedback, and appreciate nurses' efforts encourage a positive work culture. By addressing nurses' concerns rapidly and acknowledging their efforts, supervisors develop confidence and trust within the team, which improves the overall work environment in radiotherapy departments (37).

Case studies and experiences

The psychological challenges faced by nursing staff in radiotherapy departments can be better understood with case studies. Strict radiation safety procedures have a bearing on nursing staff, according to a significant study from a large US hospital. The study found that strict adherence to safety standards for the protection of both patients and staff frequently caused nurses to experience more stress and anxiety. Concerns regarding radiation exposure remained despite precautions, which had an adverse effect on well-being and work performance. Increased exhaustion among nursing staff was linked to this persistent fear (38).

Improving psychological health, treatment adherence, quality of life, and the well-being of patients and healthcare providers all rely on effective communication in oncology. Oncology nurses, however, face challenges in this regard. A total of 121 inpatient oncology nurses participated in a survey between November 2012 and March 2014, which revealed common challenges including stress management,

empathetic communication, and handling end-of-life conversations (39).

Different approaches to dealing with the psychological impacts of radiation safety protocols on nursing staff have been highlighted by experiences from radiotherapy departments around the world. Nurses at Japanese hospitals, which are known for their strict security standards, emphasized the significance of continuing education and training in reducing radiation exposure anxiety. According to these nurses, staff confidence was strengthened through methodical training programs and simulations, which helped them follow procedures successfully while safeguarding their psychological well-being (40).

The case report highlights two emergency department visits of patients that had undergone iodine-125 seed brachytherapy implanted in the abdominal wall in oncologic management. The unavailability of documented or communicated information on radiation therapy exposed the medical personnel on duty to a lot of occupational exposure. These occurrences highlight the intrinsic risks posed to the frontline clinicians due to lack of awareness and lack of documentation of the procedure of brachytherapy. To this effect, this report recommends that strong surveillance systems, specialized employee training programs, and well-defined working guidelines should be adopted to reduce this risk eventuality amid an incident (41).

In a recent study, the occupational radiation exposure of intensive care unit (ICU) nurses, who might be at risk from regular chest X-rays, was monitored. Five nurses wore film badge dosimeters for eight weeks, and three badges recorded levels beneath detection limits, while two measured 0.05 mSv each. ICU nurses would remain within recommended dose limits, according to extrapolated annual exposure. In accordance with the study's outcomes, nurses may deliver patient care without worrying about serious medical problems, as standard radiation protection measures effectively minimize exposure risks (42).

The knowledge and attitudes of final-year nursing students in the United Arab Emirates about radiation protection were studied in a 2022 online cross-sectional survey. The outcomes demonstrated that 52% of the participants were not aware of radiation protection courses and had significant knowledge gaps. Many students acknowledged the importance of radiation safety, even though they were deficient in practical knowledge about radiation risks and the ALARA (As Low As Reasonably Achievable) principle. The research emphasized the necessity for broadened educational initiatives that prepare nursing students for expected radiation safety challenges (43).

Impact of technology and innovation

Radiation oncology nurses are currently employed in a much safer environment as a result of advances in safety equipment and techniques. Radiation handling is usually dangerous for patients and medical personnel, specifically those who give treatments. Protocols have evolved as a result of the implementation of advanced safety measures such as automated shielding systems, remote-controlled devices, and real-time dosimeters. By lowering direct radiation exposure and associated anxiety, these innovations enhance patient safety while minimizing the emotional burden on nursing staff (44) (45).

During treatments, automated shielding systems minimize the necessity for manual adjustments by nursing staff by enabling efficient and precise manipulation of radiation barriers. Nurses may utilize treatment equipment remotely by utilizing the benefits of novel interfaces that provide thorough monitoring and control capabilities. By mitigating physical proximity to radiation sources, this remote functionality not only enhances safety but also preserves nurses' self-reliance when performing treatments from safer areas within the department (46).

Subsequently, technological advancements have mitigated stress among nurses by improving patient care, safety, and workflow efficiency. Fear of radiation exposure and its adverse health consequences is a major source of stress for nursing staff. Cone-beam CT and MRI-guided radiation therapy are examples of modern imaging systems that enable more precise tumor targeting, minimize the need for repeated procedures and extended exposure, and shorten the duration of treatment (47).

Additionally, new planning simulation tools and software have made it feasible for medical professionals to design customized radiation treatment plans that are suitable for each patient's distinctive anatomical and clinical requirements (48). By streamlining the treatment process, these tools free up nurses' time from administrative duties and enable them to concentrate more on offering direct patient care. By transitioning from manual to automated systems, nursing staff may offer higher-quality care with fewer administrative burdens, improve efficiency, and enhance job satisfaction (49). In conclusion, the psychological health of nursing staff in radiotherapy departments has benefited from incorporating technology into safety procedures. In addition to providing devices that enhance control, efficiency, and precision in patient care, advanced safety equipment and procedures have reduced exposure risks (50).

DISCUSSION

Improving safety procedures in radiotherapy departments and decreasing the psychological stress on nursing staff require resilient policy recommendations. Prioritizing the well-being of patients and employees also requires straightforward, comprehensive, and frequently revised regulations that integrate the most recent developments in radiation safety technology and industry best practices. To ensure that nursing staff members are adequately trained to employ safety equipment and comply with established protocols, regular workshops and training sessions should be put in place (51).

A system that enables employees to report security concerns or incidents without fear of reprisals ought to be implemented. Transparency and continuous organizational improvement can be encouraged by an anonymous evaluation procedure (52). In addition, collaboration between medical physicists, safety officers, radiation oncologists, and nursing staff is necessary (53). To assess security protocols, evaluate incidents, and define areas for improvement, regular multidisciplinary discussions should be conducted (54). By incorporating a variety of opinions into the establishment of policies, a collaborative approach encourages a team-based safety culture. Adequate funding ensures the advancement and maintenance of safety equipment, while adequate staffing levels minimize workload pressures that can result in errors. Furthermore, using technology to decrease human error and automate safety checks strengthens the efficacy of safety procedures (55).

To reduce the mental impact of working in a highly stressful environment, it is essential that nursing professionals in radiotherapy departments receive better psychological support. Detecting stress, anxiety, or exhaustion in nursing staff requires proactive steps such as routine psychological assessments. These issues can be reduced through early interventions such as counseling, support groups, and communication with mental health professionals (56). Peer support programs, in which skilled nurses offer emotional support and mentoring, foster consistency, and reduce anxiety and isolation (57).

To provide nurses with the resources they require for dealing with challenging circumstances, training programs that include stress management, resilience building, and coping strategies should be implemented on a regular basis (58). Promoting a balance between work and life is also essential, and policies that prevent excessive overtime, provide flexible scheduling, and ensure appropriate rest periods can all help minimize burnout while improving overall well-being (59). To minimize stigma, leaders must prioritize open communication, address staff concerns, and encourage open conversations about mental health to establish a supportive organizational environment. Programs that recognize the accomplishments and contributions of nursing staff can also boost morale and job satisfaction (60).

Future studies should concentrate on significant subjects for enhancing the mental health of radiotherapy nursing staff. In order to evaluate the long-term consequences of radiation exposure and safety policies, such as cumulative anxiety, burnout, and retention rates, longitudinal studies are necessary (61). The application of automation and technology to reduce stress while enhancing safety is another intriguing field of study. Research should investigate the methods by which modern technologies, including robotics, artificial intelligence, and remote surveillance systems, may help nursing staff in fulfilling their

responsibilities and reducing psychological stress (62). To further address specific challenges encountered by diverse nursing populations, attention is required to develop culturally relevant interventions. These approaches should consider factors such as socioeconomic status, gender, and ethnicity, as well as their impact on coping strategies and psychological well-being (63). Collaborative research projects by multidisciplinary teams are crucial for the beneficial development and implementation of scientifically supported treatments that strengthen psychological well-being and safety in radiotherapy departments (64).

CONCLUSION

The psychological effects of radiation security measures on radiotherapy department nursing staff highlight the serious mental health issues that these staff members encounter. As a result of close proximity to sources of radiation and stringent safety regulations, 58 studies were selected from a total of 602 records, which demonstrate the stress, anxiety, and burnout that healthcare workers endure.

The need to preserve the lives of patients and healthcare specialists promotes the need to ensure that the safety measures are directed at reducing the physical and psychological suffering. These precautions must address the issues on the short-term exposure and the possible longer-run health risks. This reiterates the important role of providing access to psychological resources, continuous training as well as conducive organizational settings. This support is necessary in order to curb the long-term anxiety that negatively influences the job satisfaction.

Technological applications, such as remote-controlled devices and automated shielding systems, may reduce radiation exposure for nursing staff and decrease psychological stress. A healthier workplace, elevated job satisfaction, and the well-being of nursing professionals in radiotherapy depend upon a multifaceted strategy that involves training, support networks, and modern technology.

Author contribution

Surgical and Medical Practices: SL; Concept: SL; Design: SL; Data Collection or Processing: SNH; Analysis or Interpretation: SL, SNH; Literature Search: SNH; Writing: SL, SNH. All authors reviewed the results and approved the final version of the article.

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Conflict of interest

The authors declare that there is no conflict of interest.

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