
***The Relationship Between Radiation Safety and Ergonomics in Healthcare
Workers: Comprehensive Protection Approaches***

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Abstract

Background: This review aims to examine the radiation and ergonomic risks faced by healthcare workers and to understand the effects of these factors on health.

Methods: We conducted a comprehensive literature search in PubMed, Scopus, and Web of Science databases. The search covered the period from January 2000 to April 2024. Healthcare workers, especially in radiology, oncology and emergency services, are exposed to high radiation doses and ergonomic problems. This study proposes a comprehensive approach to protect the physical and psychological health of healthcare workers by combining radiation safety and ergonomic measures.

Results: Radiation safety is a critical issue for healthcare workers; it can lead to health problems such as cancer and skin burns in the long term. Similarly, ergonomic risks can cause musculoskeletal problems due to incorrect sitting positions, heavy lifting and repetitive movements. These factors can directly affect the productivity and occupational health of healthcare workers.

This review emphasises that effective radiation safety protocols and ergonomic job designs play an important role in protecting healthcare workers. Risks can be reduced by measures such as training, use of technology and personal protective equipment. Furthermore, ergonomic designs can increase productivity while improving safety in the workplace.

Conclusions: Combining radiation safety and ergonomic measures, it is possible to sustainably improve the health of healthcare workers. This approach will benefit both workers and patients.

1. Introduction

Healthcare workers are routinely exposed to various physical, chemical, and biological hazards due to the nature of their duties. Among these, ionising radiation and ergonomic deficiencies represent two significant threats to both the short- and long-term health of these professionals. Radiation exposure in hospital environments impacts not only radiology specialists but also other occupational groups such as surgeons, anaesthetists, nurses, and technical staff (Rehanni et al., 2006). Ergonomic risk factors are likewise a major cause of musculoskeletal disorders (MSDs) in the healthcare sector, negatively affecting productivity, quality of life, and occupational continuity (Punnett et al, 2004).

Global systematic reviews indicate that MSDs affect up to 88% of nurses and 64% of radiology staff, primarily due to poor posture, repetitive tasks, and heavy lifting (Minghelli et al., 2021). Long-term exposure to ionising radiation is linked to an increased risk of cataracts, thyroid dysfunction, haematological abnormalities, and certain malignancies, especially among interventional radiologists and cardiologists (Kim et al. 2023, WHO 2022). Ergonomic deficiencies—such as poorly designed equipment, non-adjustable workspaces, prolonged static postures, and improper handling of patients or heavy devices—exacerbate these risks. Moreover, radiation protection tools such as lead aprons or thyroid collars, often weighing 4–8 kg, further increase the physical

burden on workers, contributing to neck, shoulder, and lower back injuries (Lee et al., 2022).

Radiation safety and ergonomics are often addressed separately, yet an integrated approach can yield dual benefits: reducing radiation exposure and mitigating physical strain. For instance, adjustable imaging tables and mobile radiation shields not only limit radiation exposure but also promote better working posture (Zhou et al., 2023). Therefore, this study examines how ergonomic strategies and radiation safety protocols can be implemented together as complementary protective measures.

2. Materials and Methods

This review synthesises findings from peer-reviewed articles, guidelines, and institutional reports published between 2000 and 2024 on radiation safety and ergonomics in healthcare settings. Literature was identified through databases including PubMed, Scopus, and Web of Science using the keywords: 'Radiation safety', 'Ergonomics', 'Musculoskeletal disorders', 'Healthcare workers', and 'Occupational safety'.

Inclusion criteria were: (1) Studies involving healthcare professionals exposed to ionising radiation; (2) Studies evaluating ergonomic interventions in clinical environments; (3) Guidelines or recommendations from recognised health authorities (e.g., WHO, ICRP).

Exclusion criteria included non-healthcare settings, non-English publications without translations, and studies with insufficient methodological details.

The extracted data were categorised under: Radiation exposure types and risks; Radiation safety principles; Ergonomic risk factors and solutions; Integration of ergonomic and radiation safety practices; and Comprehensive protection approaches.

3. Results

3.1 Radiation Exposure in Healthcare Workers

Ionising radiation—including alpha particles, beta particles, gamma rays, X-rays, and neutrons—can damage biological tissues by altering atomic structures (ICRP, 2020), Chida et al., 2021). Gamma rays and X-rays are the most prevalent in clinical practice, used extensively in diagnostic and therapeutic procedures. Occupational exposure occurs both directly and indirectly, with

interventional radiologists and cardiologists experiencing the highest cumulative doses (ICRP, 2020, Knuttinen et al., 2021).

3.2 Radiation Safety Principles

The ALARA (As Low As Reasonably Achievable) principle underpins modern radiation safety, emphasising time reduction, increased distance, and shielding (ICRP, 2020, IAEA, 2022, ICRP, 2012):

- Time: Shorter exposure durations reduce cumulative doses.
- Distance: Exposure decreases with the square of the distance from the source (inverse-square law).
- Shielding: Use of lead aprons, thyroid collars, leaded goggles, and fixed barriers.

3.3 Ergonomic Risks in Healthcare

Prolonged standing, awkward postures, repetitive movements, and manual patient handling contribute to high MSD prevalence (Aydemir et al., 2016, Lim et al., 2011). Ergonomic interventions—such as adjustable workbenches, supportive seating, and equipment designed to reduce bending and twisting—are effective in decreasing strain.

3.4 Relationship Between Radiation Safety and Ergonomics

Ergonomic designs improve compliance with radiation safety protocols. Adjustable imaging devices and mobile shielding allow safer working distances, reducing both MSD risk and radiation exposure (Rehani et al., 2006, Lim et al., 2011, Ülgüdür et al., 2020).

3.5 Comprehensive Protection Approaches **Key strategies include:**

- Physical measures: Lead aprons, ergonomic furniture, radiation barriers (Lim et al., 2011).
- Training: Combined radiation safety and ergonomic training (IAEA, 2022, Robertson et al., 2003).
- Policies: Workplace standards integrating both areas (ICRP, 2012, Ülgüdür et al., 2020).
- Health monitoring: Regular radiation dose checks and MSD screenings (Chida et al., 2021, Lim et al., 2011).
- Technology: Mobile radiation monitors, ergonomic analysis software (IAEA, 2022, Robertson et al., 2003).

4. Discussion

This review highlights that radiation safety and ergonomics share overlapping objectives in occupational health. Traditionally, they have been addressed in isolation; however, integrating them yields enhanced protection. Ergonomic interventions—when aligned with radiation safety protocols—can reduce physical strain while maintaining compliance with ALARA principles.

For instance, ergonomic workstations for interventional radiology reduce the need for prolonged static postures while enabling optimal positioning relative to radiation sources. Similarly, lighter lead apron designs or supportive exoskeletons may reduce musculoskeletal burden without compromising radiation protection (Lee et al., 2022, Lim et al., 2011).

The combined training approach is crucial: educating healthcare workers about proper posture, safe patient handling, and optimal radiation protection strategies ensures knowledge is applied holistically. Workplace policies must also mandate regular reviews, dose monitoring, and ergonomic audits.

5. Conclusion

Radiation safety and ergonomics are mutually reinforcing disciplines essential to the health and safety of healthcare workers. Integrating ergonomic interventions into radiation safety programmes reduces both MSD risk and cumulative radiation exposure.

Recommendations:

1. Implement regular, combined training on ergonomics and radiation safety.
2. Invest in ergonomic medical equipment and lighter protective gear.
3. Enforce compliance with radiation safety protocols and ergonomic regulations.
4. Conduct routine health monitoring for radiation dose and musculoskeletal health.
5. Encourage research and technological innovation in protective equipment.

By approaching these two domains together rather than separately, healthcare organisations can create safer, more sustainable working environments that preserve the long-term health of their staff.

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