BioSocial Health J 2024; 1(1): 47-52
doi:10.34172/bshj.8
https://biosocialhealthjournal.com

BioSocial Health Journal

Original Article

Relationships among health, safety and environment (HSE) factors and the radiation received and incidence of cancer among the radiologic technologists

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Abstract

Introduction: Radiologists and radiotherapists are frequently exposed to elevated levels of radiation compared to the general population. This study aimed to assess the impact of Health, Safety, and Environment (HSE) conditions on employees in radiology and diagnostic imaging services regarding the incidence of cancer.

Methods: This cross-sectional survey comprised two components: (1) Evaluation of HSE conditions in radiology and diagnostic imaging services within hospitals, and (2) Examination of radiation doses received by radiologic technologists, along with investigating cancer incidence among these workers.

Results: Among the 29 and 54 participants, the two-month and annual doses exceeded standard levels. The HSE condition survey revealed mean scores across all hospitals of 75.5 ± 10.2 for radiation safety, 88.2 ± 8.5 for general safety, and 47 ± 10.6 for emergency safety. No cases of suspected radiation-related cancer symptoms were identified. Higher scores on metrics such as individual dosimeter usage, adherence to proper Personal Protective Equipment (PPE), equipment safety checks, device leak testing, presence of safety warnings, and attention to HSE issues were associated with reduced radiation exposure and fewer doses received by participants.

Conclusion: Adherence to safety protocols leads to decreased radiation exposure and mitigates concerns regarding occupational diseases.

Keywords: Radiation, Safety, Hospitals, Occupational Diseases

Received: December 14, 2023, **Accepted**: February 12, 2024, **ePublished**: March 17, 2024

Introduction

Radiation constitutes a significant component of the human physical environment and is categorized into two main groups: ionizing and non-ionizing radiation. Of these, ionizing radiation garners greater attention due to its potential impact on public health. It poses a significant occupational hazard, capable of causing severe, irreversible, and incurable harm to those exposed.[1,2] Ionizing radiation transfers energy to cells and tissues, initiating a cascade of biological reactions ranging from immediate cellular interactions to long-term biological effects[3-9], some of which may manifest decades later. These effects encompass a spectrum from immediate symptoms such as nausea, vomiting, and fatigue to long-term conditions including various cancers (such as leukemia, bone cancer, thyroid cancer, and lung cancer) and genetic abnormalities in offspring of exposed individuals.[9]

Globally, healthcare professionals constitute approximately 12% of the workforce, operating within environments recognized as among the most hazardous occupational settings. [10,11] Radiologic technologists, in particular, are regularly exposed to substantial levels of radiation.[12] According to the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), the number of individuals exposed to radiation has increased significantly in recent years, leading to heightened concerns regarding cumulative radiation doses and potential health impacts over time. [13-14] consequently, ensuring radiation safety, particularly within healthcare facilities, is paramount.[15]

Occupational Health and Safety Management Systems (OHSMSs) represent a comprehensive approach encompassing planning, consultation, and specific program elements aimed at enhancing health and safety performance. [16, 17] Safety, in this context, refers to the extent to which potential hazards are avoided through a range of practices and ongoing activities designed to identify, eliminate, or mitigate risks. [18] Given the presence of patients, employees, students, and complex equipment within hospital environments, prioritizing safety is essential.[18]

This survey was undertaken to assess the prevalence of cancer among radiologists and radiologic technologists, who are routinely exposed to radiation, while also evaluating health, safety, and environmental conditions within radiation centers. Additionally, the survey aimed to develop a Health, Safety, and Environment (HSE) checklist to gauge the level of HSE compliance in diagnostic imaging services and ensure the well-being of personnel. The findings of this survey can inform the development and implementation of health and safety protocols, with potential applications including regulatory inspections and ongoing monitoring of HSE standards.

Material and Methods

Data Collection

This cross-sectional survey was conducted across eight hospitals, encompassing seventeen diagnostic imaging services in Tabriz, Iran. All personnel working in diagnostic imaging services with potential radiation exposure were included in the survey. The study comprises two main parts:

1) HSE Survey of Diagnostic Imaging Services: This section involved assessing the health, safety, and environment conditions in hospital diagnostic imaging and radiotherapy services, including radiology, radiotherapy, nuclear medicine, and CT scan departments. Information was collected using checklists developed by the research team, drawing on previous studies and similar checklists such as radiation safety checklist and radiation safety inspection checklist.[19,20] The final checklist comprised five sections: (a) Basic information (hospital name, department name, number of personnel, date), (b) Radiation safety (40 items), (c) Radioactive waste management (11 items), (d) General safety (20 items), and (e) Emergency safety (6 items). The reliability of the checklist was assessed using Cronbach's alpha coefficient, yielding a coefficient of 0.76, indicating acceptable reliability. Additionally, checklist validity was confirmed through expert review, ensuring alignment with the survey's objectives. Following verification of validity and reliability, scores were normalized on a scale of 0-100. Based on expert opinion, scores were categorized into four levels: weak (0-25), average (26-50), good (51-75), and very good (76-100).

2) Investigation of Radiation Dose Exposure: This part involved evaluating the radiation doses received by workers in diagnostic imaging services over two- and twelve-month periods, utilizing dosimeter results reports. These reports included data on effective doses HP10 (in mSv) and HP 0.07, as well as the total effective dose over the past 12 months, obtained from the Atomic Energy Organization of Iran (AEOI). HP (d) represents the dose equivalent at a specified depth in the human body, typically where a dosimeter is worn. HP (10) is assessed at a depth of 10 mm, representing the individual effective whole-body dose, while HP (0.07), at a depth of 0.07 mm, represents the equivalent dose to the skin and extremities.[21] Additionally, periodic tests (every 6 months) were conducted for suspected cancer cases, including complete blood count (CBC), thyroid stimulating hormone (TSH), urinalysis (U/A), triglycerides, fasting blood sugar (FBS), urea, creatinine, LDL, and HDL.

Study population

In this study, we investigated 8 hospitals, each housing a total of 17 diagnostic imaging services, including radiology, radiotherapy, nuclear medicine, angiography, among others. The collective workforce in these units comprised 303 employees, all of whom underwent evaluation to assess the dose of radiation received. Among the participants, 120 (56%) were male and 96 (44%) were female, with a mean age of 38 years old. The study focused on examining the radiation dose received by employees working in the radiation section under three conditions: HP (10) mSv, HP (0.07) mSv, and the dose received over a 12-month period.

Statistical analysis

Quantitative data were presented as mean ± standard deviation, while qualitative data were expressed as frequency and percentage. To compare the number of employees with normal and abnormal doses, as well as to compare checklist section adherence between normal and abnormal groups, the chi-square test and t-test were employed, respectively. Additionally, to compare hospitals based on checklist item adherence, analysis of variance (ANOVA) and the Tukey post hoc test were utilized.

Results

Among the subjects examined, the maximum dose received was 0.96 mSv, the minimum was 0, and the mean total dose received was 0.031 ± 0.11 mSv, which is below 0.05 mSv over a two-month period. Notably, the dose received in terms of HP (0.07) mSv over two months for all subjects was below the standard level (under 0.05 mSv). However, the dose received in terms of HP (10) over two months exceeded the standard level for 29 individuals (10%). Additionally, the annual dose received analysis revealed that among the 303 individuals, no cases were found where the effective dose of HP (10) over twelve months exceeded the standard limit of 20 mSv.

Regarding health, safety, and environment assessments, as detailed in Table 1, the overall scores obtained across all hospitals were 75.5 ± 10.2 for radiation safety, 88.2 ± 8.6 for general safety, and 47 ± 10.6 for emergency safety. It was observed that general safety scored higher than other sections of the checklist in all hospitals. Upon reviewing the final results in terms of adherence to safety

Table 1. Scores obtained separately for each item

Items	Yes		No		Irrelevant	
	Number	%	Number	%	Number	%
(a) Radiation safety						
Availability and observable of warning posters	14	82.4	3	17.6	0	0.0
Appropriate warning posters	15	88.2	1	5.9	1	5.9
Prohibition of non-expert and irresponsible people	17	100	0	0.0	0	0.0
Availability of rules and regulations	5	29.4	12	70.6	0	0.0
Availability of radiation safety procedure	6	35.3	11	64.7	0	0.0
Staff equipped with dosimeter or Thermoluminescent Detectors (TLD)	17	100	0	0.0	0	0.0
Prohibition of eating, drinking and using jewelry	2	11.8	15	88.2	0	0.0
Appropriate use of PPE	12	70.6	5	29.4	0	0.0
Availability of disinfection in entrance	8	47.1	9	52.9	0	0.0
Availability of up-to-date radioactive receiving regulation	1	5.9	0	0.0	16	94.1
Availability of up-to-date rules on how to use radioactive devices	1	5.9	0	0.0	16	94.1
Weekly check of contaminant	1	5.9	0	0.0	16	94.1
Availability of documented and proceeding of checking contaminant	5	29.4	0	0.0	12	70.6
Performing and document biological monitoring	6	35.3	0	0.0	11	64.7
Availability of radioisotopes label	2	11.8	0	0.0	15	88.2
Perform leaky teat every 6 months	17	100	0	0.0	0	0.0
Access to seasonal (3 months) checking of equipment safety	17	100	0	0.0	0	0.0
Documenting of annual inspection	17	100	0	0.0	0	0.0
Control rooms labeling with appropriate warning	16	94.1	0	0.0	0	0.0
Availability of 12 months calibration	17	100	0	0.0	0	0.0
Access to safety and operating procedure	8	47.1	9	52.9	0	0.0
Wounds and scratches are covered	16	94.1	1	5.9	0	0.0
Separation of radiation area with room of the films and documents	15	88.2	2	11.8	0	0.0
Availability eye washer and emergency washer	3	17.6	14	82.4	0	0.0
Physical separating of lab and film store	12	70.6	5	29.4	0	0.0
Dosage into operating area is more than 2.5 mSv	15	88.2	2	11.8	0	0.0
Effective dose into general place was 1 mSv	15	88.2	2	11.8	0	0.0
Biological checking test perform for carrier	0	0.0	1	5.9	16	94.1
Availability of fume hood for radioactive material	2	11.8	0	0.0	15	88.2
Using of radioactive material inside or outside of body	1	5.9	4	23.5	12	70.6
Checking and monitoring of contaminant is done	3	17.6	0	0.0	14	82.4
Providing the checking place on the map	5	29.4	12	70.6	0	0.0
Results documentation is available	7	41.2	0	0.0	10	58.8
Availability of clearing ways	4	23.5	0	0.0	23	76.5
Cleaning procedure is appropriate	2	11.8	0	0.0	25	88.2
Reported contaminant	2	11.8	0	0.0	15	88.2
The carrier of radioisotopes have person dosimeter	1	5.9	0	0.0	16	88.2
Carriers have TLD rings	1	5.9	0	0.0	16	94.1
TLD bags store away from radiation area	16	94.1	0	0.0	1	5.9
TLD bags will check and results are returned	17	100	0	0.0	0	0.0
(b) General safety						
Radiation licenses are affixed to all radiation places	11	64.7	6	35.3	0	0.0
Safety warning and safety sings are placed in the entrances	16	94.1	1	5.9	0	0.0
CNSC safety and TDG posters are mounted	17	100	0	0.0	0	0.0

Table 1. Continued.

Items	Yes		No		Irrelevant	
	Number	%	Number	%	Number	%
Radioactive material exactly identified and have been tagged	4	23.5	2	11.8	11	64.7
Confirmed personnel lists are available	15	88.2	2	11.8	0	0.0
Warning sign used appropriately	17	100	0	0.0	0	0.0
Radioactive signs mounted on the lead boiler	0	0.0	0	0.0	17	100.
The store of material is ordered and have been tagged	4	23.5	0	0.0	13	76.5
Lab is ordered and free of nonspecific material	17	100	0	0.0	0	0.0
Availability of operation procedure	6	35.3	11	58.8	0	0.0
Supplier sources are labeled "High voltage "	8	47.1	8	47.1	1	5.9
Power supply is clearly marked "Danger–high voltage"	11	58.8	6	35.3	1	5.9
The power "ON" switch is readily accessible	16	94.1	0	0.0	1	5.9
Off/on key is available	16	94.1	0	0.0	1	5.9
All electrical facilities are protected from operator contact	16	94.1	0	0.0	1	5.9
All of the electrical cable has insulation	16	94.1	0	0.0	1	5.9
AC energy source has earth contact	16	94.1	0	0.0	1	5.9
Safety cover unit is interlocked	17	100	0	0.0	0	0.0
Supply energy and unite located away from sink	16	94.1	0	0.0	1	5.9
Related personnel are trained to do Cardiopulmonary resuscitation	17	100	0	0.0	0	0.0
(c) Emergencies						
Emergency contacts/spill procedure poster is posted	2	11.8	15	88.2	0	0.0
Emergency procedures are followed in case of spill or contamination.	12	70.6	5	29.4	0	0.0
All spills, accidents or exposures are reported to the laboratory supervisor and the Radiation Safety Office	17	100	0	0.0	0	0.0
An Emergency Plan is available to all laboratory personnel	0	0.0	17	100	0	0.0
All radiation users listed on the permit are knowledgeable to spill response procedures, containment, decontamination and reporting procedures	17	100	0	0.0	0	0.0
Emergency procedures are available	0	0.0	17	100	0	0.0

PPE, Personal Protective Equipment

protocols across all hospitals, it was noted that 3 (18%) of the departments were in very good condition, 13 (76%) were in good condition, and 1 (6%) was in average condition. Regarding health and waste management, only two hospitals had radioactive waste management systems in compliance with internal regulations set by the Atomic Energy Organization of Iran (AEOI).

Furthermore, an analysis of the relationship between the number of individuals receiving standard and non-standard doses revealed a significant correlation ($P < 0.001$). Similarly, a significant correlation ($P < 0.001$) was observed between adherence to checklist sections and cases of standard and non-standard received doses. This indicates that hospitals or departments with better adherence to radiation safety checklist items tended to have lower levels of radiation exposure among personnel. (Table 2).

Discussion

This study aimed to assess the impact of Health, Safety, and Environment (HSE) conditions on employees in radiology and diagnostic imaging services, particularly regarding the incidence of cancer. [22] The annual dose limit of 20 mSv for whole-body effective dose was selected based on the International Commission on Radiological Protection guidelines, 1991, in order to enhance study sensitivity. Comparable to our findings, A. Szumska et al. reported that in the majority of cases, HP (10) and HP (0.07) doses remained below 0.1 mSv per 3 months, with only a negligible percentage exceeding the average annual dose limit for workers.[23]

Furthermore, our investigation of Radiologic technologists for suspected cancer symptoms related to radiation exposure yielded no confirmed cases, with only three individuals exhibiting minor health issues such as thyroid inflammation and platelet deficiency. This aligns with the findings of Orme et al.[24] Previous studies have not conclusively linked cancer incidence to doses below 200-400 mSv, possibly explaining the absence of cancer cases in our study.[25-27] However, some research has associated cancers among radiologists with radiation exposure.

Our study underscores the importance of adherence

Table 2. The dose received by the employees of radiology and radiotherapy departments in the studied hospitals

Type of received dose	Mean ± SD*	Minimum	Maximum	Frequency of standard dose	Percent	Frequency of nonstandard dose	Percent
HP(10) (mSv)	0.03 ± 0.11	0.00	0.98	274	90.4	29	9.6
HP(0.07) (mSv)	0.00 ± 0.00	0.00	0.00	303	100	0.00	0.00
12 months	0.16 ± 0.51	0.00	4.56	249	82.2	54	17.8

SD, standard deviation.

to health and safety principles, as evidenced by the positive correlation between high scores on items such as individual dosimeter usage, proper personal protective equipment utilization, equipment safety checks, device leak testing, presence of safety warnings, and attention to HSE issues, and reduced radiation exposure among participants. Notably, no statistically significant relationship was found between these safety measures and cancer incidence among radiologists working in radiation departments. Hence, it can be inferred that maintaining a positive attitude and adhering to safety and health protocols positively impacts the overall health of employees in these departments.

Conclusion

Concerns regarding radiation exposure, particularly among radiologists, have garnered increased attention in recent decades due to their frequent exposure to ionizing radiation. The findings of this study emphasize that adherence to safety principles not only leads to reduced radiation doses but also alleviates anxiety surrounding the risk of occupational diseases. Thus, ensuring the health and occupational safety of radiologists is of paramount importance.

In light of these findings, it is imperative to prioritize the safety of radiology departments and ensure strict adherence to health and safety protocols across all departments involved in radiation-related work. Continuous monitoring and controls should be implemented to maintain optimal safety conditions.

Efforts should be directed towards ongoing education and training for radiologists and other personnel to enhance their awareness of radiation safety practices. Additionally, regular assessments of workplace conditions, equipment maintenance, and adherence to safety guidelines are essential to mitigate risks associated with radiation exposure.By prioritizing safety and implementing robust measures to protect radiologists and other healthcare professionals, we can safeguard their well-being and promote a healthier work environment in radiology departments and beyond.

Authors' Contribution

Conceptualization: Reza Dehghanzadeh.
Data curation: Pejman Azmoon.
Formal analysis: Pejman Azmoon.
Funding acquisition: Reza Dehghanzadeh.
Investigation: Reza Dehghanzadeh, Pejman Azmoon.
Methodology: Pejman Azmoon.
Project administration: Reza Dehghanzadeh.
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Competing Interests

The authors declare that they have no competing interest.

Ethical Approval

This study was approved by Ethical Committee of Tabriz University of Medical Sciences (Ethical Number: IR.TBZMED.VCR.REC.59633).

Funding

This research protocol was supported by Health and Environment Research Center (HERC), Tabriz University of Medical Sciences (grant number: IR.TBZMED.VCR.REC. 59633).

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