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Enhancing radiation safety awareness and practices among female radiographers: a comprehensive approach

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Abstract

Objective This study evaluates the level of radiation safety awareness and adherence to protective practices among pregnant female radiographers in the United Arab Emirates, aiming to identify gaps and develop targeted interventions for enhancing occupational safety.

Methods Employing a cross-sectional design, the study surveyed 133 female radiographers using a self-developed questionnaire covering demographics, awareness and knowledge, workplace practices, communication, and satisfaction.

Results The survey showed high awareness among radiographers, with 97% acknowledging radiation risks during pregnancy, although 42.9% had not received formal training. Concerns over long-term health effects were significant, with 66.2% of participants worried about potential impacts. Despite these concerns, 83.5% had been informed about radiation risks and protective measures, indicating active information provision in many workplaces. However, inconsistencies in information dissemination across different work settings were noted.

Conclusions The findings highlight the need for standardized radiation safety protocols for pregnant radiographers. The variability in safety training and information dissemination suggests the importance of establishing uniform safety practices. Recommendations include developing comprehensive education and training programs for pregnant radiographers, ensuring open communication for radiation safety and pregnancy-related concerns, and enforcing clear guidelines for workplace accommodations.

Keywords Radiographer, Radiation Safety, Radiation Awareness, Pregnant Female radiographers, Radiation Protection, Occupational Safety

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Introduction

Radiation safety among pregnant radiographers is a topic of concern. Most diagnostic and therapeutic procedures in diagnostic radiography and nuclear medicine involve doses much lower than the exposure associated with fetal harm. However, specific procedures such as radiation therapy, multiple Computed Tomography (CT) scans, specific therapies in nuclear medicine, and invasive radiology can potentially cause severe damage to the fetus [1–3]. Estimating the dose delivered to the fetus and ensuring justification and dose optimization are recommended.

When a female radiographer or any pregnant worker is exposed to ionizing radiation, there are significant concerns regarding the potential health effects on the developing fetus. Compared with adults, fetuses are at greater risk for specific radiation-induced effects [4]. Fetal development is a delicate process, especially during the first trimester when the organs are forming. The developing fetus is highly susceptible to the harmful effects of ionizing radiation. Exposure to radiation during the early stages of pregnancy can significantly heighten the chances of experiencing miscarriages. Developmental abnormalities can occur if the fetus is exposed to ionizing radiation, especially at higher doses. This poses a risk of congenital disabilities and other complications. Exposure to ionizing radiation has the potential to cause cognitive impairments and neurological effects, which can vary depending on the timing and level of exposure.

The fear of fetal exposure to radiation during pregnancy may lead to prolonged interruption in the careers of radiology workers, predominantly female radiographers. Providing accurate information and support to pregnant radiographers is essential to alleviate their concerns and ensure their safety and well-being [2]. Radiology radiation safety protocols for pregnant employees emphasize minimizing ionizing radiation exposure due to fetal risk. Recommendations limit no more than one mSv post-pregnancy declaration and optimize work practices to minimize fetal exposure [5, 6]. Job adjustments may involve reassignment to lower exposure areas, with stringent restrictions on working with unsealed radioactive sources to prevent contamination. Additional measures include avoiding high scatter radiation environments, using protective equipment, and formal pregnancy declarations to enact stricter monitoring and protection. Pregnant radiology workers may have concerns about accurately monitoring and estimating the radiation dose to the fetus. Dosimetry techniques strive to track exposure levels as precisely as possible, addressing any uncertainty regarding dose. Work limitations and stigma can arise due to concerns about radiation exposure during pregnancy. Consequently, job satisfaction and career progress may be impacted, and there is a risk

of unintentionally creating stigma in the workplace. Legal and ethical considerations come into play in regard to ensuring the safety of pregnant women without discrimination or involuntary reassignment [7–12].

Due to these concerns, it is critical to have stringent safety protocols to ensure that radiation exposure for pregnant radiology workers is well below the recommended limits and to provide thorough counseling on the risks and protection measures available [13].

Fetal ionizing radiation exposure impacts female radiographers' careers, including potential job interruptions, reduced work hours, and the need for reassignments away from high-radiation areas, which may hinder professional growth and specialization, particularly in fields such as interventional radiology. Additionally, it can lead to perceived inequities within the workplace, affecting the field's diversity and inclusivity. Addressing these challenges requires providing accurate information, implementing effective protective measures, and ensuring supportive workplace policies to foster an inclusive environment that accommodates the needs of pregnant radiographers without compromising their career progression [2, 14].

This study aimed to evaluate the level of radiation safety awareness and adherence to protective practices among female radiographers to identify gaps and develop targeted interventions for enhancing occupational safety.

Methods

Study design and setting

The study adopts a cross-sectional design, targeting female radiographers in healthcare facilities offering radiographic services in the United Arab Emirates.

Participants

This study focused on female radiographers to assess their radiation safety awareness and practices. Only those working in environments with radiation exposure risks who agreed to participate were included. This approach ensures a detailed investigation of radiation safety relevant to this group's distinct risks.

Sample size and sampling

Submitting the survey to approximately 170 female radiographers and receiving 133 responses resulted in a 78.2% response rate during the study period. This high level of engagement underlines the study's effectiveness in capturing a representative sample of the target population, ensuring that the findings on radiation safety awareness and practices among pregnant female radiographers are robust and statistically significant. The sample size was established using a finite population correction formula, considering a total population of 272 radiographers [15]. This calculation targeted a 5% margin of error and

a 95% confidence level. With these statistical parameters, the study aimed to include 170 radiographers. Data collection for the study was conducted over a three-month period, starting in July 2023.

Instrument for data collection

The survey design for this study integrates a comprehensive questionnaire with 28 questions across five specific sections to examine female radiographers' experiences and perspectives on radiation protection during pregnancy. These sections include:

1. **Demographic Information:** Basic demographic information such as age, qualifications, and years of experience was collected.
2. **Awareness and Knowledge:** Assess the radiographers' awareness of the risks associated with radiation exposure during pregnancy and their formal training in radiation protection.
3. **Workplace Practices and Communication:** Explore the operational aspects of their job, including the use of radiation-emitting equipment, the information received about radiation risks, and the comfort level, when discussing pregnancy-related radiation safety concerns with supervisors.
4. **Radiation Exposure Management:** Enquires about workplace regulations, practices for minimizing exposure, and the availability and use of personal protective equipment (PPE).
5. **Satisfaction & Challenges:** Gauge satisfaction with workplace support regarding radiation protection and any obstacles to discussing pregnancy-related radiation safety concerns.

This structured approach aims to provide a holistic understanding of the current state of radiation safety practices among pregnant female radiographers and identify areas for improvement.

The questionnaire was a self-developed instrument compiled through extensive literature review [7, 8, 12, 16]. Before distributing and finalizing the survey, a pilot study was conducted involving five senior female radiographers and a radiation safety officer to test its reliability and relevance. Their insights and feedback were pivotal in refining the survey. Specifically, modifications were made to clarify question wording and restructure or remove ambiguous items, thereby improving the survey's comprehensiveness and effectiveness in capturing precise data on radiation safety practices and awareness among pregnant female radiographers. It is important to note that the responses from the pilot study were excluded from the final data analysis to maintain the integrity of the data. Consent was obtained from all participants before initiating the survey, with clear communication

that they had the right to withdraw at any point prior to the final submission. This was to ensure ethical compliance and participant awareness. Regarding the data collection procedure, the survey was administered electronically over a three-month period starting in July 2023. This method was chosen to facilitate a broad distribution while allowing for an efficient collection of responses. Participants were given a four-week window to respond to the survey, with reminders sent bi-weekly to maximize response rates. These details are crucial for researchers who might wish to replicate the study in different contexts, providing a clear framework for the data collection process and timeline.

Data analysis

Statistical analysis was conducted using SPSS software (version 23) to assess trends in radiation safety awareness and best practices among pregnant radiographers. Chi-square tests explored associations with demographic variables, with findings presented via frequency distributions and cross-tabulations. The significance threshold was set at a p -value of <0.05 , aiming to precisely guide safety interventions.

Ethical consideration

The study received approval from the Institutional Research Unit at the University of Sharjah, reference number REC-23-09-12-01-F. Participants were briefed about the study's aims, assured of their privacy, and informed of their right to withdraw at any stage. An online Google Forms consent form was used to make sure that only those who gave their permission filled out the poll. This kept the information private and followed ethical standards. So that participants could remain anonymous, all survey data was erased and stored safely on encrypted computer that only the research team could access.

Results

Demographic and professional profile

Table 1 outlines the demographics and professional details of the 133 female radiographers surveyed. The preponderance of the respondents ($n=67$, 50.4%) were younger than 30 years, while the rest were between 31 and 40 years ($n=45$, 33.8%), 41 and 50 years ($n=18$, 13.5%), and older than 51 years ($n=3$, 2.3%). Most had a bachelor's degree ($n=101$, 75.9%), followed by a master's degree ($n=14$, 10.5%), a diploma ($n=16$, 12%), and a PhD ($n=2$, 1.5%). Regarding workplace settings, most participants ($n=89$, 66.9%) worked in hospitals, while others worked in clinics ($n=44$, 33.1%). A majority received their degree from the United Arab Emirates (UAE) ($n=84$, 63.2%), with the rest from Arab countries ($n=23$, 17.3%) and other countries ($n=26$, 19.5%). Radiography

Table 1 Demographic and professional profiles of female respondents

		n	%
Age	< 30 years	67	50.4
	31–40 years	45	33.8
	41–50 years	18	13.5
	> 51 years	3	2.3
Highest Qualification	Diploma	16	12.0
	Bachelor’s Degree	101	75.9
	Master’s Degree	14	10.5
	PhD	2	1.5
Workplace	Hospital	89	66.9
	Clinic	44	33.1
Country obtained degree	UAE	84	63.2
	Arab Countries	23	17.3
	Others	26	19.5
Imaging Modalities	Radiography	96	72.1
	CT	31	23.3
	Nuclear Medicine	6	4.5

was the most common imaging modality ($n=96$, 72.1%), followed by CT ($n=31$, 23.3%) and nuclear medicine ($n=6$, 4.5%).

Participants’ experiences with pregnancy while working in the radiology department

Participants’ experiences with pregnancy while working in the radiology department varied. Of those surveyed, a significant majority ($n=109$, 81.9%) planned to become pregnant, with ($n=53$, 39.8%) experiencing pregnancy during their tenure. Among these, ($n=18$, 33.9%) reported health issues related to pregnancy, while a smaller group ($n=7$, 13.2%) reported specific medical conditions. Regarding delivery outcomes, most of the

pregnancies resulted in normal delivery ($n=32$, 60.4%) and were full-term ($n=41$, 77.4%), Table 2.

Evaluating awareness, training, and concerns regarding radiation safety among pregnant workers in radiology departments

The comprehensive analysis of survey responses regarding awareness, training, concerns, and information dissemination about radiation exposure during pregnancy within radiology departments yields informative insights. A vast majority of respondents ($n=129$, 97.0%) affirmed their awareness of radiation risks during pregnancy at their workplace, showcasing a high level of awareness. In contrast, a small fraction of respondents ($n=4$, 3.01%) indicated a lack of awareness, highlighting a minor gap in knowledge dissemination.

There is a varied landscape for formal training on pregnancy radiation protection. Some respondents ($n=57$, 42.9%) reported never receiving formal training, indicating a significant opportunity to improve educational programs. Conversely, some respondents stated that they received training during the induction program ($n=41$, 30.8%), and others attended informative sessions for pregnant workers ($n=35$, 26.3%), reflecting some efforts to educate employees about radiation safety.

When exploring concerns about the lasting impacts of radiation, many of them expressed worries about the potential long-term health effects on themselves or their children during pregnancy ($n=88$, 66.2%), underscoring the need to address these concerns through better risk communication and support. Despite these worries, most respondents ($n=111$, 83.5%) received information about radiation risks and protective measures for pregnant staff members, suggesting that many workplaces actively provide the necessary information. However,

Table 2 Experiences with pregnancy while working in the radiology department

	Response	n	%
Do you have a plan to get pregnant?	Not sure	24	18.0
	Yes	109	82.0
Were you pregnant while working?	No	80	60.2
	Yes	53	39.8
Did you experience health issues while pregnant and working in the radiology department?	NA	80	60.2
	No	35	26.3
	Yes	18	13.5
Do any of your children have any medical conditions?	NA	80	60.2
	No	46	34.6
	Yes	7	5.3
Did you have a normal delivery?	NA	80	60.2
	No	21	15.8
	Yes	32	24.1
Did you have a full-term pregnancy?	NA	80	60.2
	No	12	9
	Yes	41	30.8

Table 3 Awareness, training, and concerns regarding radiation safety

	Response	n	%
Are you aware of the risks of radiation exposure during pregnancy at your workplace?	No	4	3.0
	Yes	129	97.0
Have you been formally trained in pregnancy radiation protection?	During the induction program	41	30.8
	Informative session organized for pregnant workers	35	26.3
	Never received any formal training	57	42.9
Are you worried about radiation's lasting impact on your health or your child during pregnancy?	No	45	33.8
	Yes	88	66.2
Have you received information about radiation risks and protective measures for pregnant staff members?	No	22	16.5
	Yes	111	83.5

Table 4 Workplace practices and communication

	Response	n	%
How comfortable are you discussing your pregnancy with your supervisor or manager about radiation safety concerns?	Very uncomfortable	1	0.8
	Uncomfortable	13	9.8
	Neutral	36	27.1
	Comfortable	29	21.8
	Very comfortable	54	40.6
Opinions on Work nature change during pregnancy	Change to nonionizing radiation	94	70.7
	Workload Reduction	39	29.3
Do you expect responsibility adjustments due to your pregnancy and radiation concerns?	No	50	37.6
	Yes	83	62.4
Describe the accommodation.	Light duty	31	23.3
	Administrative work	51	38.3
	No response	51	38.3

other respondents ($n=22$, 16.54%) had not received such information, indicating inconsistencies in information provision across different workplaces, Table 3.

These insights highlight a strong awareness among most participants regarding radiation risks during pregnancy, coupled with a clear call for enhanced formal training and consistent dissemination of information to address existing concerns and gaps.

Navigating pregnancy in radiology departments: comfort, expectations, and accommodations

In our analysis of radiology department workers' responses regarding pregnancy, we uncovered a landscape marked by openness, anticipation for change, and the provision of accommodations. Most respondents ($n=54$, 40.6%) felt comfortable discussing pregnancy-related radiation safety concerns with their supervisors. This level of comfort suggests a supportive communication environment in many workplaces. However, some discomfort remains, as evidenced by a few respondents ($n=13$, 9.8%) feeling uncomfortable and a small percentage ($n=1$, 0.8%) reporting being very uncomfortable, highlighting areas where dialogue between supervisors and employees could be improved.

When considering changes in work nature due to pregnancy, respondents preferred adaptation: some advocated for workload reduction ($n=39$, 29.3%), and others

favored a shift to roles involving nonionizing radiation ($n=94$, 70.7%), reflecting a broad consensus on the need to modify work responsibilities for safety. Furthermore, participants ($n=83$, 62.4%) anticipated adjusting their responsibilities due to pregnancy and radiation concerns, indicating a strong demand for workplace flexibility and support.

The accommodations described by respondents further illustrate the efforts made to adapt work roles for pregnant employees, with administrative work ($n=51$, 38.3%) and light duty ($n=31$, 23.3%) being the most frequently cited adjustments. These practical measures demonstrate the adjustments being implemented and reflect a commitment to preserving the health and well-being of employees during pregnancy, Table 4.

The chi-square analysis showed no statistically significant association between place of work and comfort level ($\chi^2 [2]=0.146$, $p=.930$). Comfort levels did not show significant differences between participants working in hospitals versus those in clinics. However, the significant chi-square result ($\chi^2 [2]=7.177$, $p=.028$) indicates a likely relationship between being pregnant while working in radiology and comfort levels. Specifically, pregnant radiographers reported higher comfort levels (75.5%) compared to their nonpregnant colleagues (53.8%).

Analysis of radiology department workers' responses regarding pregnancy reveals a generally supportive

environment with a strong demand for workplace flexibility and effective accommodations. However, some discomfort in communication and a need for improved dialogue between supervisors and employees remain.

Support and challenges in radiation protection for pregnant radiographers

In the survey examining workplace regulations and satisfaction with support regarding radiation protection during pregnancy, most respondents ($n=110$, 82.7%) confirmed that their workplace had established regulations or accommodations to minimize radiation exposure for pregnant employees. Conversely, a few others ($n=23$, 17.3%) indicated a lack of such measures in their workplaces, Table 5.

The responses vary regarding satisfaction with workplace support and the provision of information concerning radiation protection during pregnancy. A majority ($n=47$, 35.3%) reported neutral feelings, suggesting that while some information and support are provided, there might be room for enhancement. Meanwhile, other respondents ($n=42$, 31.6%) expressed high satisfaction, describing themselves as very satisfied with the support and information available. Additionally, a significant portion ($n=41$, 30.8%) also reported feeling content, indicating their satisfaction. On the other end of the spectrum, a small minority ($n=2$, 1.5%) found themselves dissatisfied with the provided support and information, and an even smaller fraction ($n=1$, 0.8%) reported being very dissatisfied.

The chi-square test revealed no statistically significant associations between satisfaction with workplace support or information and whether the participants experienced pregnancy in the radiology department ($\chi^2 [2]=4.442$,

$p=.109$). Furthermore, the chi-square test indicated no statistically significant association between place of work and satisfaction with workplace support and information ($\chi^2 [2]=1.697$, $p=.428$). This suggests that satisfaction levels with support and information did not differ significantly between participants working in hospitals and those working in clinics.

Discussion

This paper underscores the importance of radiation safety for pregnant radiographers, focusing on the potential health risks that ionizing radiation poses to both employees and fetuses. It is acknowledged that in well-designed radiology departments, where appropriate safety protocols and PPE are utilized, occupational exposure levels are typically maintained well below the 1 mSv annual limit. Even in higher-exposure environments like interventional radiology or PET, doses generally do not exceed this limit. However, the fetus’s heightened vulnerability during the first trimester necessitates stringent safety measures. While the overall risk of miscarriages, developmental issues, and cancer is low at these exposure levels, the potential consequences for the developing fetus demand a cautious and proactive approach to radiation protection. Thus, a balanced strategy is advocated to ensure the health and safety of pregnant radiographers while supporting their professional advancement without undue discrimination in potentially high-exposure environments [17].

The results showed the need for standardized radiation safety protocols for pregnant radiographers [13, 18]. This need is underscored by the general awareness of radiation risks during pregnancy among radiographers, which contrasts with the considerable variability in the quality and

Table 5 Radiation exposure management

	Response	n	%
Do your workplace regulations have measures or accommodations to minimize radiation exposure during pregnancy?	No	23	17.3
	Yes	110	82.7
How can a female radiographer maintain radiation protection practices?	Following workplace guidelines	112	84.2
	Limiting exposure time	97	72.9
	Notifying colleagues about your pregnancy	99	74.4
	Using personal protective equipment (PPE)	95	71.4
What measures can you take at your workplace if you get pregnant?	Reduce workload	96	72.2
	Change modalities	96	72.2
	None of the above	10	7.5
How satisfied are you with your workplace’s support and information regarding radiation protection during pregnancy?	Very dissatisfied	1	0.8
	Dissatisfied	2	1.5
	Neutral	47	35.3
	Satisfied	41	30.8
Have you faced any obstacles discussing your pregnancy-related radiation safety concerns with colleagues or supervisors?	Very satisfied	42	31.6
	No	105	78.9
	Yes	28	21.1

uniformity of safety training and information dissemination. The survey's findings agree with the literature that highlights existing awareness but points to shortcomings in the practical application of this knowledge. Studies and results underscore the variability in workplace support and the adequacy of information on radiation safety for pregnant radiographers, suggesting inconsistencies across different work settings. Establishing these standards is pivotal for improving the implementation of safety practices and enhancing the confidence and well-being of pregnant radiographers in their work environments. Embedding continuous professional development tailored to the needs of pregnant radiographers could lead to significant advancements in occupational health and safety standards within the field of radiography.

Radiographers' concerns about the long-term effects of radiation on their health and that of their children are crucial. Comfort in discussing these issues with supervisors is vital for positive work experience and safety adherence. A supportive work environment that encourages open communication is essential. Supervisors should be accessible and proactive in addressing concerns, emphasizing the need for continuous education on radiation safety. Effective communication within the workplace can enhance job satisfaction, staff retention, and overall safety in the radiology department, contributing to better workplace practices and patient care quality [19].

Workplace adjustments for pregnant radiographers, such as workload reduction and reassignment, aim to protect both their health and the fetus's health. Satisfaction with these changes varies, highlighting a balance between health, safety, and career progression. Some areas needing improvement include formalizing policies to consistently apply accommodations and involving radiographers in decision-making to align adjustments with professional goals. Ensuring opportunities for professional development and transparency in adjustments can improve satisfaction, fostering an inclusive workplace culture that supports radiographers' return to their roles post pregnancy.

Compliance with protective measures to minimize radiation exposure among radiographers is generally high, yet there is notable variability in implementing these measures across workplaces. While some institutions strictly enforce safety protocols and provide access to essential protective equipment, others may lack resources or prioritize safety less. This inconsistency indicates the need for industry-wide standardization and robust safety cultures to ensure uniform protection for all radiographers, irrespective of their work setting [20, 21]. Addressing these discrepancies is crucial for maintaining high levels of occupational safety within the radiology field. The study's potential limitations include a restricted geographical and demographic scope, and the risk that

self-reported practices may not accurately represent actual behaviors.

Recommendation

The need for comprehensive policies and practices to ensure the safety and support of pregnant radiographers is critical, as evidenced by gaps highlighted in the literature and the variability in safety practice implementation. Based on the insights gained from the study, the following is recommended:

1. A comprehensive education and training program focused on radiation safety specifically designed for pregnant radiographers should be developed and implemented.
2. The establishment of mandatory, regular training sessions that include the latest research on the effects of radiation exposure during pregnancy is needed.
3. A supportive environment encouraging open communication between radiographers and management of radiation safety and pregnancy-related concerns should be created.
4. Clear guidelines for workplace accommodations, including the provision of appropriate protective equipment and the option for reassignment to lower-risk duties, should be enforced.
5. A workplace culture that values pregnant radiographers' health and career progression should be cultivated, actively preventing discrimination and unnecessary barriers.

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12913-024-11369-2>.

Supplementary Material 1

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Author contributions

MA conceptualized and approved the research, oversaw data collection, drafted the manuscript, and reviewed the final submission. WE and ZH were responsible for data collection, analysis, and interpretation. HA contributed to the survey design, writing the discussion, and reviewing the final manuscript for submission. All authors read and approved the final manuscript."

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Data availability

Data availability The data of this study is available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent

This research received approval from the University of Sharjah Research Ethics Committee, under Reference number REC-23-09-12-01-F. We obtained consent from all participants before initiating the survey, ensuring they were informed of their right to withdraw from the study at any point prior to the final submission.

Consent for publication

NA.

Competing interests

The authors declare no competing interests.

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