SJST
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Surman Journal for Science and Technology
ISSN: Online (2790-5721) - Print (2790-5713)
مجلة صرمان للعلوم والتقنية
Vol 7, No.2, Jun - Dec. 2025
Pages: 105 ~ 117

Public Awareness and Knowledge of Ionizing Radiation Risks from Medical Imaging Examinations in Western Libya

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الملخص

هدفت هذه الدراسة المقطعية إلى تقييم مستوى معرفة ووعي المجتمع بالمخاطر المرتبطة باستخدام الإشعاع المؤين في الفحوصات الطبية، إضافة إلى استكشاف مصادر المعلومات المفضلة وطرق التواصل الأكثر فعالية. شملت العينة (172) مشاركًا، كانت غالبيتهم من الإناث (66.5%) ومن الفئة العمرية 25–35 سنة (49.4%)، كما أن معظمهم يحملون مؤهلًا جامعيًا (75.3%). أظهرت النتائج أن المعرفة العامة محدودة؛ حيث بلغ الوعي بفحوصات شائعة مثل الأشعة السينية (61.4%) وأشعة الأسنان (44.4%) مستوى متوسطًا، في حين أن أكثر من نصف المشاركين (56.9%) لم يتمكنوا من التمييز بين الإجراءات المؤينة وغير المؤينة. كما لوحظت فجوات مهمة تتعلق بمستويات الجرعة، والعوامل المرتبطة بالمريض (مثل الوزن)، والمخاطر النسبية لوسائل التصوير المختلفة. وقد قيَّم معظم المشاركين مستوى معرفتهم بأنه متوسط أو ضعيف (63.2%)، فيما كانت الإنترنت ووسائل التواصل الاجتماعي المصدر الرئيس للمعلومات (48.5%). وأفاد ما يقارب نصف المشاركين (50%) بعدم تلقيهم أي معلومات متعلقة بالمخاطر أثناء الفحص، على الرغم من تفضيلهم الواضح أن تتم عملية التواصل من قبل أطباء الأشعة (57.3%) وفنيي الأشعة (43.9%)، إضافة إلى رغبتهم في الإبلاغ عن الجرعات بوحدات قياس قياسية(41.5%) . أظهر تحليل (Chi-square) وجود ارتباطات ذات دلالة إحصائية ($p < 0.05$) بين المتغيرات الديموغرافية ومستوى المعرفة. تؤكد هذه النتائج وجود فجوات حرجة في المعرفة وأساليب التواصل، مما يستدعي تنفيذ برامج تثقيفية منظمة، وتحسين التواصل بين المرضى ومقدمي الخدمة، إلى جانب دمج المنصات الرقمية لتعزيز الممارسات الآمنة في استخدام الأشعة الطبية.

الكلمات المفتاحية: الإشعاع المؤين، التصوير الطبي، الوعي الصحي، المعرفة المجتمعية.

Abstract

This cross-sectional study evaluated public knowledge and awareness of ionizing radiation risks in medical imaging, alongside preferred information sources and communication methods. A total of 172 participants were surveyed, predominantly female (66.5%) and aged 25–35 years (49.4%), with most holding a university degree (75.3%). Overall knowledge was limited: while awareness of common examinations such as X-ray (61.4%) and dental radiography (44.4%) was moderate, more than half (56.9%) could not distinguish ionizing from non-ionizing procedures. Significant gaps were noted regarding dose levels, patient-related factors (e.g., weight), and the relative risk of imaging modalities. Most participants rated their knowledge as moderate or poor (63.2%), with the internet and social media (48.5%) serving as primary information sources. Nearly half (50%) reported receiving no risk-related information during examinations, despite a clear preference for communication by radiologists (57.3%) and technologists (43.9%), and for reporting doses in standard units (41.5%). Chi-square analysis revealed statistically significant associations ($p < 0.05$) between demographic variables and knowledge-related responses. These findings highlight critical knowledge and communication gaps, underscoring the need for structured educational interventions, improved patient–provider communication, and the integration of digital platforms to promote safe medical radiation practices.

Keywords: Ionizing radiation, medical imaging, health awareness, community knowledge

Submitted: 13/08/2025 *Accepted: 12/09/2025*

I. INTRODUCTION

Ionizing radiation resulting from medical examinations is considered one of the most important diagnostic and therapeutic tools that have significantly contributed to the advancement of modern medical practices (Abdallah, 2017). The use of X-rays, computed tomography (CT), and nuclear medicine imaging has provided wide-ranging possibilities for the early detection of diseases and precise localization, leading to improved diagnostic accuracy, enhanced treatment outcomes, and higher recovery rates (Azman et al., 2019). Despite these considerable medical benefits, ionizing radiation is a double-edged sword, as its use involves radiation doses that may have cumulative effects on living tissues in cases of unjustified or repeated exposure (Alavi et al., 2017).

Medical radiation exposure constitutes the largest source of human exposure to ionizing radiation from man-made activities compared to other sources such as industry or the environment. Reports from the International Atomic Energy Agency (IAEA) and the World Health Organization (WHO) indicate that the substantial increase in diagnostic imaging procedures over recent decades has contributed to a global rise in radiation dose levels received by individuals (WHO, 2020; Demeter et al., 2016). This highlights the necessity of enhancing public awareness and knowledge regarding this issue (Sherfad et al., 2024; Abdalla et al., 2024).

Community awareness and accurate understanding of the nature of medical radiation, its doses, risks, and protective measures are fundamental pillars for ensuring the optimal use of these examinations. A lack of sufficient knowledge may lead to the spread of misconceptions, such as the belief that all medical imaging is entirely safe, or conversely, exaggerated fear of radiation that may prevent some patients from benefiting from its diagnostic and therapeutic advantages (Al-Mallah et al., 2017). Hence, the importance of studies assessing public knowledge and awareness toward ionizing radiation becomes evident, particularly in light of its widespread and increasing use (Bolbol et al., 2021).

Moreover, strengthening health literacy regarding radiation is not limited to patients but also extends to their families and the general public. This contributes to supporting informed medical decision-making and promotes active patient–physician participation (Ahn et al., 2017). Awareness of radiation protection principles, such as the "ALARA" rule (As Low As Reasonably Achievable), plays a vital role in minimizing unnecessary radiation exposure while maintaining a balance between maximizing medical benefits and reducing potential risks (Alyousef et al., 2023).

Based on the above, this study aims to shed light on the level of public knowledge and awareness concerning ionizing radiation from medical examinations, to identify gaps in community understanding of its risks and benefits, and to propose practical strategies to enhance health and radiation literacy, thereby ensuring optimal utilization of these vital diagnostic tools and minimizing potential harm.

II. METHODOLOGY

1. Study Design

This descriptive-analytical study was conducted on a sample of 172 participants, including patients and members of the general public, in the western region of Libya. Data were collected using a specially designed electronic questionnaire, which included an informed consent form to ensure adherence to ethical standards in scientific research.

2. Inclusion Criteria

The study included all individuals from the general public and patients who were over 18 years old, voluntarily agreed to participate in the study, and were able to understand and complete the electronic questionnaire.

3. Exclusion Criteria

Participants under 18 years of age, those who did not consent to participate, those who did not complete the questionnaire in full, or those with difficulties accessing electronic platforms were excluded from the study.

4. Study Instrument

The study employed a structured questionnaire consisting of 25 questions, organized into three main sections. The first section focused on demographic data, including age, gender, and educational level. The second section assessed participants' knowledge of the risks associated with ionizing radiation from medical examinations and their awareness of its potential effects on sensitive organs. The third section explored sources of information related to medical radiation and the preferred methods through which participants obtained such information.

5. Study Procedures

The questionnaire was distributed via multiple electronic platforms to maximize reach and ensure representation from different demographic groups. Its content was developed after a comprehensive review of relevant literature to ensure validity and reliability. The Arabic version of the questionnaire was reviewed by expert specialists, and a pilot study was conducted on a small subset of participants to confirm the clarity, accuracy of phrasing, and ease of comprehension.

6. Data Analysis

Following data collection, responses were coded and entered into SPSS version 26 (IBM Corp., Armonk, NY, USA) for statistical analysis. Descriptive statistics were applied, including frequencies, percentages, means, and standard deviations, to summarize participants' demographic characteristics and knowledge levels.

For inferential analysis, the Chi-square (χ^2) test was used to examine associations between categorical demographic variables (e.g., gender, age group, and educational level) and knowledge-related responses. A p-value < 0.05 was considered statistically significant. In addition, results were visualized using charts and graphs to facilitate clear presentation and interpretation of the findings.

III. RESULTS

1- Demographic Data of Participants

A total of 172 individuals participated in the study. As shown in Table (1), females constituted the majority at 66.5% compared to 34.3% males. Regarding age, the most represented group was 25–35 years, accounting for 49.4%, followed by those under 25 years at 29.4%, while participants over 40 years were the least represented at 5.9%. In terms of educational level, the results indicated that the majority of participants held a university degree (75.3%), followed by postgraduate degree holders (15.1%), while those with less than a secondary education were very limited (1.2%). Concerning occupational status, more than half of the participants were employed in the public sector (51.8%), followed by students (24.7%), and those working in the private sector (12.4%). The unemployed and self-employed groups represented smaller proportions, accounting for 3.5% and 7.6%, respectively.

Table (1): Demographic characteristics of the study participants (N = 172)

Variable	Category	Frequency	Percentage (%)
Gender	Female	113	66.5%
	Male	59	34.3%
Age	< 25 years	50	29.4%
	25 – 35 years	85	49.4%
	36 – 40 years	27	15.9%
	> 40 years	10	5.9%
Educational Level	Below secondary	2	1.2%
	Secondary	16	9.4%
	University degree	128	75.3%
	Postgraduate studies	26	15.1%
Employment Status	Student	42	24.7%
	Government employee	89	51.8%
	Private sector employee	21	12.4%
	Unemployed	7	3.5%
	Self-employed	13	7.6%

2- Knowledge Assessment

This section of the questionnaire aimed to evaluate the participants' level of knowledge regarding different radiological examinations, sources of ionizing radiation, and their awareness of radiation doses and associated risks. The questions addressed multiple aspects, including the types of examinations the participants had undergone and their frequency, knowledge of natural sources of ionizing radiation, the ability to distinguish between examinations involving ionizing and non-ionizing radiation, understanding of dose levels in various procedures, and awareness of the age groups most susceptible to radiation risks.

Table 2: Participants' Knowledge Section Responses (N = 172)

No.	Question	Response	Percentage (%)	p-value
1	Radiological examinations previously undergone	Body X-ray	61.4	0.021*
		Dental X-ray	44.4	
		CT scan	17.5	
		MRI	16.4	
		Ultrasound	15.8	
		Mammogram	2.3	
		PET/Nuclear scan	1.8	
		None	22.8	
2	Examinations performed more than 3 times	Body X-ray	38.9	0.034*
		Dental X-ray	29.6	
		CT scan	5.8	
		MRI	5.3	
		Ultrasound	7.0	
		PET/Nuclear scan	0.6	
		None	37.7	
3	Children (<14 yrs) who underwent radiological exams	Yes	20.9	0.048*
		No	79.0	
4	Existence of a natural source of ionizing radiation	Yes	47.6	0.012*
		No	8.2	
		I don't know	44.4	
5	Examinations that may cause the body to emit radiation afterward	I don't know	53.4	0.006**
		All of the above	22.6	
		Nuclear imaging	18.7	
		Ultrasound with contrast	2.3	
		CT with contrast	1.8	
		None	1.2	
6	CT abdominal dose comparison (60 kg vs. 100 kg person)	I don't know	58.1	0.027*
		Higher in heavier	19.9	
		Equal	12.3	
		Higher in lighter	9.9	

The analysis of participants' responses revealed significant patterns regarding exposure to radiological examinations and awareness of radiation-related concepts. The most commonly experienced procedures were body X-rays (61.4%) and dental X-rays (44.4%), while advanced modalities such as CT (17.5%), MRI (16.4%), ultrasound (15.8%), and mammograms (2.3%) were less frequent. Notably, 22.8% of participants reported never undergoing any radiological examination. This distribution was statistically significant ($p = 0.021$), indicating variations in exposure across demographic groups.

Repeated exposure was largely limited to body X-rays (38.9%) and dental X-rays (29.6%), with much lower rates for CT, MRI, or ultrasound (<8%). Approximately 37.7% reported no examination repeated more than three times, reflecting a preference for repeated low-dose imaging compared to restricted use of high-dose procedures ($p = 0.034$).

Regarding pediatric imaging, only 20.9% reported that children under 14 years had undergone radiological examinations, while 79% responded "no" (p = 0.048). This finding suggests cautious parental decision-making, likely influenced by awareness of radiation risks in children.

In terms of knowledge, 47.6% of participants correctly identified natural sources of ionizing radiation, whereas 44.4% responded "I don't know" (p = 0.012), highlighting a considerable gap in basic environmental awareness. Similarly, when asked about examinations that may cause the body to emit radiation afterward, more than half (53.4%) were uncertain, and only 18.7% correctly recognized nuclear imaging (p = 0.006).

Dose awareness was also limited: 58.1% did not know how CT abdominal dose varies with patient weight, and only 19.9% correctly indicated higher dose in heavier patients (p = 0.027).

Overall, while familiarity with common imaging such as X-rays was relatively high, participants showed substantial knowledge deficits in critical areas including radiation sources, dose variability, and post-examination effects. These gaps, supported by statistically significant associations, emphasize the need for targeted educational programs to improve public radiation literacy and promote safe imaging practices.

Table 3: Participants' Knowledge Section Responses (N = 172)

No.	Question	Response	Percentage (%)	p-value
5	Examinations involving ionizing radiation	I don't know	56.9	0.001**
		CT scan	25.7	
		MRI	19.3	
		Mammogram	15.2	
		Ultrasound	4.1	
6	Examination delivering the highest radiation dose	I don't know	44.1	0.019*
		Both are equal	27.9	
		Chest CT	17.5	
		Chest X-ray	10.5	
9	Hazard level of ionizing radiation examinations	I don't know	41.8	0.041*
		Slightly hazardous	31.0	
		Very hazardous	18.1	
		Not very hazardous	9.4	
10	Group most vulnerable to radiation risks	I don't know	34.8	0.015*
		Equal	18.1	
		Elderly	6.4	
		Middle-aged	2.9	
		25-year-old man	0.6	
		25-year-old woman	0.0	

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مجلة صرمان للعلوم والتقنية
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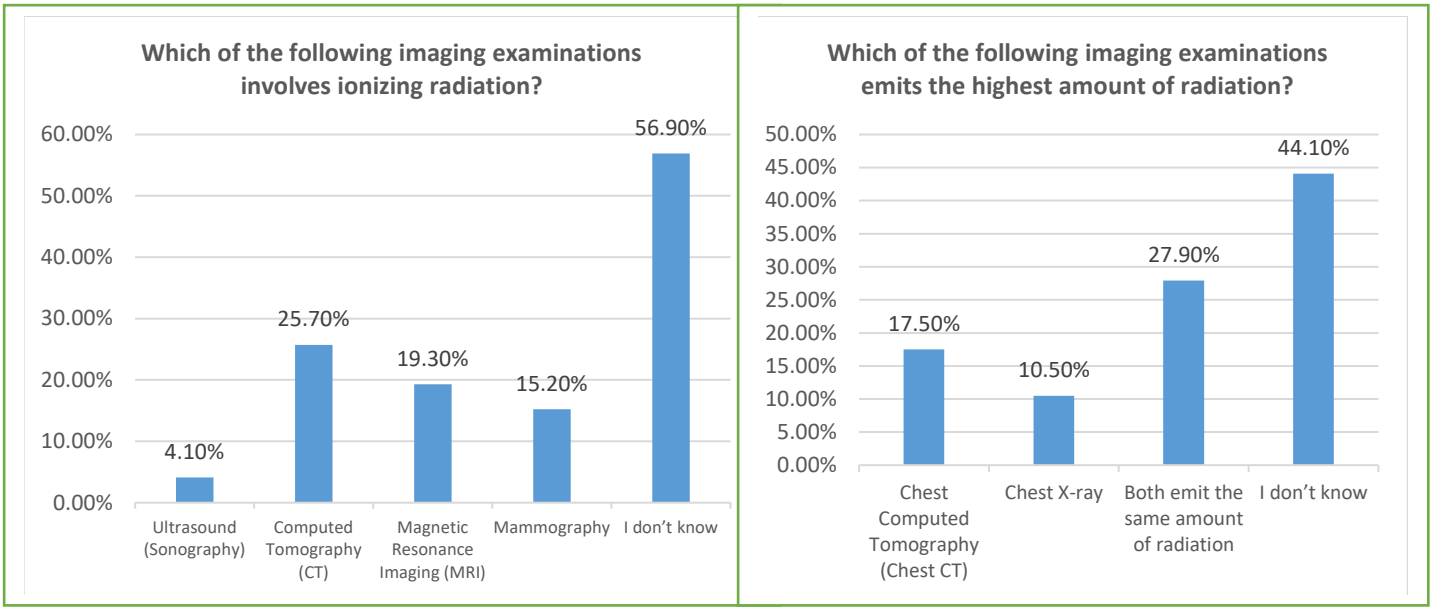

Figure 1 shows that 56.9% did not know, 25.7% correctly identified CT, while 19.3% incorrectly selected MRI and 15.2% selected mammogram. The association was highly significant ($p = 0.001$*), indicating that misconceptions about which modalities involve radiation remain widespread. The second figure illustrates that only 44.1% did not know, while only 17.5% correctly identified chest CT, compared to 10.5% who incorrectly selected chest X-ray. The difference was statistically significant ($p = 0.019$), confirming poor understanding of relative radiation dose levels.

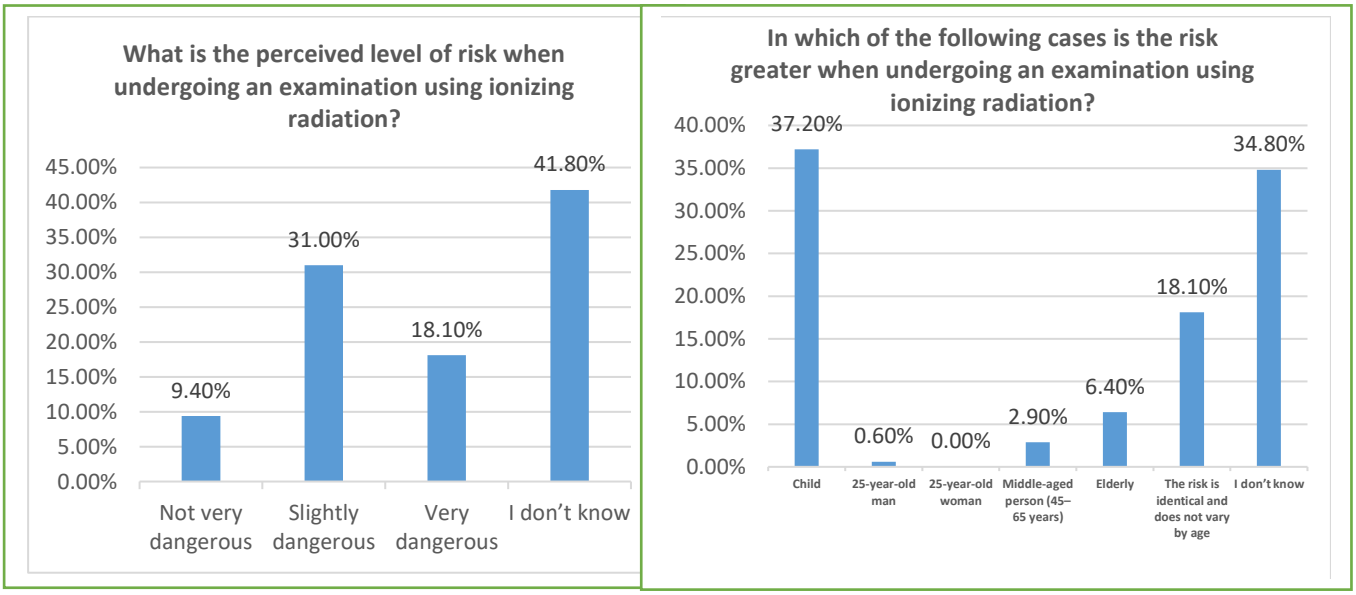

Figure 2: shows variability in participants' awareness of ionizing radiation risks, with 41.8% responded "I don't know," 31.0% believed they were "slightly hazardous," and only 18.1% considered them "very hazardous." The Chi-square test confirmed significant differences across responses (p = 0.041), demonstrating uncertainty and underestimation of risks among participants. The second chart shows 34.8% answered "I don't know," 37.2% correctly identified children, while only small percentages chose elderly or adults. The difference was statistically significant (p = 0.015), reinforcing that awareness of pediatric sensitivity exists but overall knowledge remains fragmented.

3- Communication

This section of the questionnaire aimed to evaluate participants' knowledge of the risks associated with the medical use of ionizing radiation, as well as to explore the sources from which they obtain information and their experience in receiving such information during medical examinations. Additionally, it investigated participants' preferences regarding the channels and entities from which they prefer to receive awareness, along with their preferred method of being informed about the radiation doses they are exposed to. The findings were organized into six main themes, corresponding to the questions presented in Table 2. The analysis revealed that a significant proportion of participants still demonstrate insufficient knowledge. Most participants relied primarily on the Internet and social media as their main sources of information, while exposure to traditional media and printed materials was limited. Only a small percentage reported receiving information about radiation risks during imaging procedures, whereas the majority expressed a preference to receive this information from specialized healthcare providers, particularly radiologists. Regarding the preferred method of dose communication, over one-third of participants preferred to receive the dose in official radiation measurement units, others preferred comparisons with familiar risks such as smoking or travel, and a notable proportion indicated no desire to receive any information.

Table 4: Participants' Knowledge Section Communication (N = 172)

Question	Response Options	Frequency	Percentage	p-value
1. How do you rate your knowledge of the risks associated with the medical use of ionizing radiation?	Excellent	10	5.8%	0.002*
	Good	35	20.5%	
	Average	46	26.9%	
	Adequate	18	10.5%	
	Inadequate	63	36.6%	
2. What are your sources of information about the risks associated with the medical use of ionizing radiation?	Television or radio	14	8.2%	0.001*
	Newspapers and magazines	3	1.8%	
	Internet and social media	84	48.5%	
	Booklets	8	4.7%	
	School or university	44	25.7%	
	I have no information	63	36.8%	
3. When you underwent an ionizing radiation examination, did you receive any information about the associated risks?	Yes	18	10.5%	0.003*
	No	86	50%	
	I have never undergone such an examination	68	39.8%	
4. From which of the following sources would you like to receive information about the risks associated with the medical use of ionizing radiation?	Television or radio	23	13.5%	0.001*
	Newspapers and magazines	9	5.3%	
	Internet and social media	99	57.9%	
	Booklets	12	7%	
	School or university	47	27.5%	
	Healthcare providers	71	41.3%	

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مجلة صرمان للعلوم والتقنية
Vol 7, No.2, Jun - Dec. 2025
Pages: 105 ~ 117

5. From which healthcare providers would you like to receive information about the risks associated with the medical use of ionizing radiation?	Radiologist	98	57.3%	0.002*
	Medical physicist	52	30.4%	
	Radiology technologist	76	43.9%	
	General practitioner	26	15.2%	
6. At the end of the radiological examination, how would you prefer to be informed about the radiation dose you received?	Radiation dose in measurement units	72	41.5%	0.005*
	Equivalent number of cigarettes	28	16.4%	
	Equivalent number of exposure days	29	17%	
	Equivalent number of kilometers traveled by car	16	9.4%	
	I do not want to be informed	51	29.8%	

The results demonstrated significant gaps in communication with patients regarding ionizing radiation risks, as nearly half (50%) reported not receiving any information, while 39.8% had never undergone such examinations. Only 10.5% were informed during the procedure ($p = 0.003$), reflecting insufficient patient education protocols.

Participants preferred digital platforms, especially internet and social media (57.9%), as primary sources of information, followed by healthcare providers (41.3%) and educational institutions (27.5%), with traditional media cited far less ($p = 0.001$). Radiologists (57.3%) and radiology technologists (43.9%) were the most trusted healthcare providers, compared to medical physicists (30.4%) and general practitioners (15.2%) ($p = 0.002$).

Regarding communication of radiation dose, 41.5% favored standardized measurement units, while others preferred simplified analogies (days of exposure, cigarettes, or travel distance). Notably, 29.8% did not wish to receive such information ($p = 0.005$).

Overall, the findings underscore inadequate direct communication during examinations and a growing reliance on digital media and specialized providers. This highlights the need for multi-level strategies that combine scientific accuracy with simplified, patient-friendly explanations to improve awareness of radiation risks.

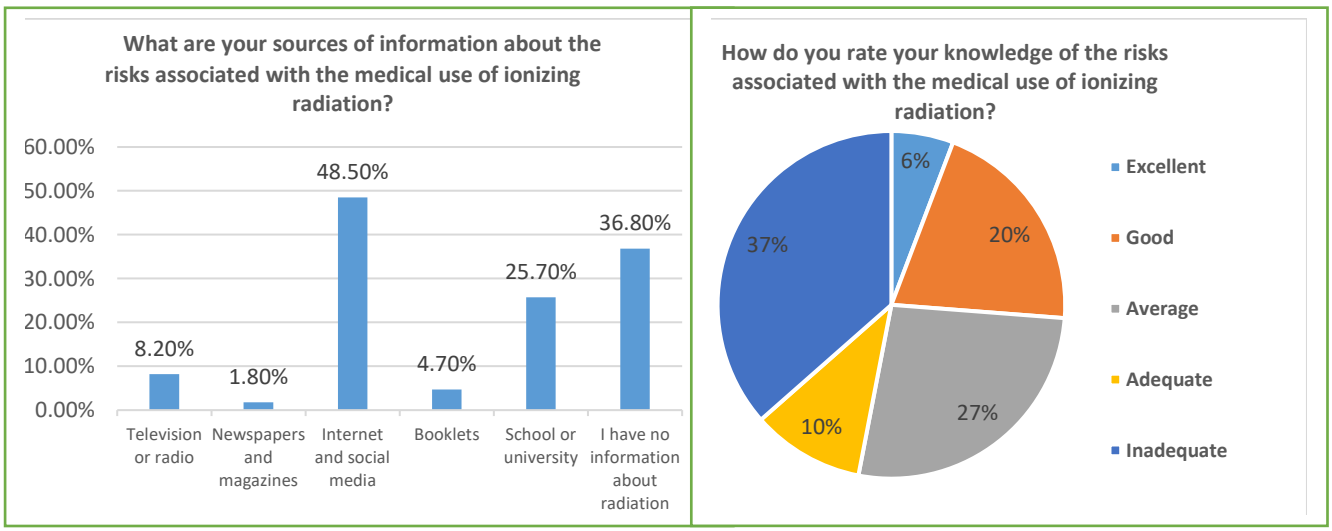

Figure 3 shows that 63.2% of participants rated their knowledge of medical radiation risks as moderate or low, reflecting a clear knowledge gap and highlighting the need to strengthen specialized awareness and training programs. The results also indicate variability in knowledge sources, with 48.5% relying on the Internet and 25.7% on schools and universities, while traditional media were the least used. Notably, 36.8% of participants reported having no information, underscoring the importance of promoting health education through reliable sources.

IV .Discussion

This study confirms a marked deficiency in public knowledge of ionizing radiation from medical imaging in western Libya, aligning with recent Libyan data from Misurata and Alkhoms (Sherfad et al., 2024; Abdalla et al., 2024) and similar findings from Bahrain (Al-Mallah et al., 2017), Saudi Arabia (Alhasan et al., 2015), and Jordan (Azman et al., 2019). Despite a high proportion of university-educated participants, misconceptions about CT dose, natural background radiation, and risk variability by age and body size were frequent, consistent with international reports (Demeter et al., 2016; Ditkofsky et al., 2016). Beyond individual knowledge gaps, these findings reflect structural and cultural factors within the healthcare system. Limited patient–provider communication may result from heavy clinical workloads, the absence of standardized counseling protocols, and insufficient training of healthcare workers in risk communication. Cultural perceptions of medical imaging as routine and harmless may also contribute to underestimating radiation risks. The community's heavy reliance on the Internet and social media for radiation information, combined with minimal counseling by healthcare providers, underscores the need for structured, multi-level educational interventions. Hospitals and radiology departments should adopt standardized patient-communication guidelines, while national campaigns and school curricula can help correct misinformation and improve baseline knowledge. Digital platforms—already the primary sources of information—represent a valuable opportunity to disseminate evidence-based, culturally tailored content to the wider public. Future research should expand to other Libyan regions and explore demographic predictors of knowledge to guide targeted interventions, while longitudinal or mixed-method studies could provide deeper insights into the effectiveness of educational strategies and the long-term impact of awareness programs on patient behavior and radiation safety practices.

V .Limitations

This study has several limitations that should be considered when interpreting the findings. First, the relatively small sample size (N = 172) and the use of a convenience sampling strategy may limit the generalizability of the results to the broader Libyan population. Second, data were collected through an online self-administered questionnaire, which could introduce selection bias by favoring participants with internet access and basic digital literacy. Third, knowledge and awareness were assessed through self-reported responses, which may be subject to recall bias or social desirability bias.

Finally, the cross-sectional design prevents establishing causal relationships between demographic factors and knowledge levels. Future studies with larger, randomly selected samples and mixed-method designs are recommended to validate and expand these findings.

VI. Conclusion

The findings indicate a low level of awareness and knowledge about the risks of ionizing radiation from medical examinations, with participants relying heavily on informal sources such as the internet and social media and receiving limited direct education from healthcare providers. These results highlight the need to strengthen health education through targeted awareness programs that address varying knowledge levels and cultural backgrounds, as well as public campaigns to inform the population about radiation risks and protective measures. It is recommended to train healthcare professionals to communicate information clearly and simply, provide reliable resources via official websites and publications, and incorporate radiation safety topics into school and university curricula. Additionally, further studies are needed to identify the causes of knowledge gaps and to compare findings across different regions for a broader understanding of the issue.

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