

## Research Article

# Digital Radiology Literacy: Public Awareness and Perception of Radiation Risks and Benefits in the Era of Increasing Diagnostic Imaging in Punjab

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**Abstract:** **Introduction:** With the rapid expansion of diagnostic imaging and digital healthcare services, public understanding of radiation risks and benefits has become increasingly important. Digital radiology literacy plays a key role in shaping patient's acceptance and appropriate utilization of imaging services. This study evaluated digital radiology literacy, perception of radiation risks and benefits, and utilization patterns among the general population of Punjab. **Methods:** A community-based cross-sectional study was conducted over four months using a self-administered Google Form questionnaire. Adults aged  $\geq 18$  years residing in Punjab were included, excluding healthcare professionals. A total of 420 valid responses were analysed. The survey assessed socio-demographic variables, digital radiology literacy (20 items), perception (20 statements), and utilization patterns (20 items). Data were analysed using descriptive statistics, Chi-square test, and Pearson's correlation ( $p < 0.05$ ). **Results:** Most participants were aged 26–35 years (29.0%), female (53.3%), and urban residents (71.9%). High awareness was observed for ultrasound use in pregnancy (83.8%) and its working principle (81.9%), whereas knowledge was lower for nuclear medicine (51.9%), PET utility (53.8%), and radiation dose concepts (51.0%). Literacy levels were excellent in 22.9% and good in 42.4% (mean  $13.4 \pm 3.2$ ). Imaging utilization was high (80.0%), largely physician-advised (71.9%); however, only 51.0% recalled radiation counselling and 52.9% reported cost influencing decisions. Education, income, occupation, and age showed significant associations with literacy, perception, and utilization ( $p < 0.05$ ). Literacy correlated positively with perception ( $r = 0.482$ ) and utilization ( $r = 0.536$ ) ( $p < 0.01$ ). **Conclusion:** Although digital radiology literacy in Punjab is moderate-to-good, important gaps and misconceptions persist, particularly regarding advanced imaging and radiation risk. Strengthening patient-centred education and standardized radiation communication is essential to ensure safe and informed imaging utilization.

**Keywords:** Digital radiology literacy; Diagnostic imaging; Radiation awareness; Imaging utilization; Public perception; Punjab.

## INTRODUCTION

The rapid expansion of digital health technologies has transformed the landscape of diagnostic medicine worldwide. Among these advancements, digital radiology has emerged as a cornerstone of modern clinical practice, enabling faster image acquisition, enhanced resolution, seamless storage through Picture Archiving and Communication Systems (PACS), and improved interdisciplinary communication. Modalities such as digital X-ray, computed tomography (CT), magnetic resonance imaging (MRI), ultrasound, and nuclear medicine now play an indispensable role in early diagnosis, treatment planning, disease monitoring, and preventive healthcare.<sup>1-3</sup>

In parallel with technological growth, the volume of diagnostic imaging has increased substantially. Greater availability of imaging centres, improved healthcare infrastructure, and broader insurance coverage have

contributed to rising utilization rates, including in Indian states such as Punjab. While increased access enhances diagnostic precision and patient outcomes, it also raises important questions regarding public understanding of radiation risks, benefits, and appropriate use of imaging investigations.<sup>4,5</sup>

Digital radiology literacy—defined as the public's ability to understand the purpose, safety, benefits, and potential risks of imaging modalities—has become increasingly relevant in this context. Although many individuals are familiar with common investigations such as digital X-ray or ultrasound, awareness of which modalities involve ionizing radiation, how radiation dose varies between tests, and when imaging is medically justified remains inconsistent. Misconceptions, such as believing that all imaging tests are harmful or that repeated scans inevitably lead to severe health consequences, may

create anxiety and influence healthcare decisions. Conversely, inadequate awareness of radiation exposure may contribute to unnecessary demand for advanced imaging without proper clinical indication.<sup>6-8</sup>

Balancing the benefits of diagnostic imaging with the principles of radiation safety is a key public health priority. Rational imaging requires informed patients who understand not only the potential risks but also the substantial clinical benefits when investigations are appropriately indicated. Effective patient–physician communication depends on a baseline level of digital health literacy, particularly in an era where health information—both accurate and misleading—is widely circulated through online platforms and social media.<sup>9,10</sup>

Punjab, characterized by improving literacy rates, expanding private and public diagnostic facilities, and

increasing digital connectivity, provides an important setting to evaluate community-level digital radiology literacy. However, limited data exist on how the general population perceives radiation risks and benefits in the context of growing diagnostic imaging utilization. Understanding these perceptions is essential for designing targeted educational strategies, strengthening risk communication, and promoting evidence-based imaging practices.

Therefore, the present study aims to assess public awareness of digital radiology, evaluate perceptions regarding radiation risks and benefits, and examine how these factors influence imaging-related decision-making among the general population of Punjab. By exploring digital radiology literacy at the community level, this study seeks to contribute to the development of informed, rational, and patient-centred diagnostic imaging practices.

## MATERIALS AND METHODS

### Study Design and Setting

A community-based, descriptive cross-sectional study was conducted to assess digital radiology literacy, awareness of radiation risks and benefits, and perceptions regarding increasing diagnostic imaging among the general population of Punjab, India. The study was carried out over a four-month period (October, 2025 --January, 2026) using a structured, self-administered Google Form questionnaire. The digital format was chosen to ensure wide geographic coverage, ease of participation, and inclusion of respondents from both urban and semi-urban regions of the state.

### Study Population

The study population comprised adults aged 18 years and above who had been residing in Punjab for at least one year. Participants were required to have the ability to read and understand the questionnaire independently and provide voluntary informed consent.

### Inclusion Criteria:

- Adults ( $\geq 18$  years) residing in Punjab for  $\geq 1$  year
- Willing to participate and provide digital informed consent
- Able to complete an online questionnaire independently

### Exclusion Criteria:

- Healthcare professionals (including doctors, radiologists, radiographers, nurses, and medical students) to avoid professional knowledge bias
- Incomplete or duplicate responses
- Respondents residing outside Punjab

### Sample Size Determination

The sample size was calculated using the single population proportion formula, assuming a 50% expected level of adequate digital radiology literacy (in the absence of prior regional data), a 95% confidence interval, and a 5% margin of error. The minimum calculated sample size was 384 participants. To compensate for potential incomplete responses and improve precision, the final target sample size was increased to 420 respondents.

### Sampling Technique and Data Collection

A non-probability convenience sampling method was adopted. The Google Form survey link was distributed through social media platforms (WhatsApp, email, Facebook), community groups, educational institutions, and resident welfare associations across Punjab. Efforts were made to ensure representation across different age groups, genders, educational levels, and socioeconomic backgrounds.

The first section of the form included a brief description of the study purpose, assurance of confidentiality, and an informed consent statement. Only participants who provided consent could proceed to complete the questionnaire. The average completion time was approximately 10–15 minutes. No personally identifiable information was collected.

### Data Collection Instrument

A structured and pre-tested questionnaire was developed after reviewing relevant literature on radiation literacy, digital health awareness, and imaging utilization. The questionnaire was designed in simple, non-technical language to ensure clarity for the general population.

**The instrument consisted of four sections:**

**Section I: Socio-Demographic Characteristics**

This section collected data on age, gender, educational status, occupation, monthly household income, and area of residence (urban/semi-urban).

**Section II: Digital Radiology Awareness**

**This section assessed knowledge regarding:**

Common imaging modalities (digital X-ray, CT, MRI, ultrasound, nuclear medicine)

- Identification of ionizing vs non-ionizing modalities
  - Basic understanding of radiation dose
  - Awareness of digital storage systems (e.g., PACS, digital reports)
  - Indications and benefits of imaging
- Each correct response was awarded one point; incorrect or “don’t know” responses were scored zero.

**Section III: Perception of Radiation Risks and Benefits**

Participants responded to statements addressing:

- Fear of radiation exposure
- Perceived cancer risk from imaging
- Beliefs regarding safety of repeated scans
- Trust in physician recommendations
- Perceived necessity vs overuse of imaging

Responses were recorded using a three-point Likert scale (Agree, Neutral, Disagree). Scientifically accurate responses were scored accordingly to generate a perception/misconception score.

**Section IV: Imaging Utilization and Digital Behaviour**

This section explored:

- History of undergoing imaging
- Frequency of imaging in recent years
- Whether imaging was physician-advised or self-requested
- Awareness of radiation counselling before scans
- Influence of cost and digital report accessibility
- Use of online sources for imaging-related information

**Scoring Criteria**

Digital radiology literacy scores were calculated by summing correct responses from the awareness section.

**Scores were categorized as:**

- Excellent:  $\geq 75\%$  correct responses
- Good: 50–74%

- Fair: 25–49%
- Poor:  $< 25\%$

Perception scores were categorized into low misconception, moderate misconception, and high misconception levels based on total correct responses. Utilization patterns were analyzed descriptively and categorized into appropriate, moderate, low, or poor utilization levels based on defined scoring thresholds.

Radiation literacy was operationally defined as the ability to correctly identify imaging modalities involving ionizing radiation and to differentiate them from radiation-free modalities.

**Validation and Reliability**

The questionnaire underwent content and face validation by an expert panel comprising a radiologist, a public health specialist, and a biostatistician. Necessary modifications were made to enhance clarity, relevance, and scientific accuracy.

A pilot study was conducted among 40 respondents (excluded from final analysis) to assess clarity, feasibility, and internal consistency. Reliability analysis using Cronbach’s alpha demonstrated good internal consistency ( $\alpha \geq 0.80$ ).

**Data Management and Statistical Analysis**

Responses were automatically captured through Google Forms and exported to Microsoft Excel for cleaning and coding. Statistical analysis was performed using IBM SPSS Statistics (Version 26.0). Descriptive statistics (frequency, percentage, mean, and standard deviation) were used to summarize socio-demographic characteristics, awareness levels, perception scores, and utilization patterns.

Inferential statistics included Chi-square test to assess associations between digital radiology literacy & socio-demographic variables and Pearson’s correlation coefficient to evaluate relationships among awareness, perception, and utilization scores. A p-value  $< 0.05$  was considered statistically significant.

**Ethical Considerations**

Participation was voluntary, and digital informed consent was obtained before proceeding with the questionnaire. Anonymity and confidentiality were strictly maintained throughout the study. No personal identifiers were collected, and data were used solely for academic research purposes.

## RESULTS

The study included 420 participants, predominantly aged 26–35 years (28.1%), followed by 18–25 years (24.3%) and 36–45 years (22.9%). Females constituted 54.8% of the sample. Most respondents were graduates (43.3%) or postgraduates (38.1%), and 40.0% were service/professionals. A substantial proportion reported monthly household

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 income between ₹25,001–50,000 (33.3%). The majority resided in urban areas (73.3%), indicating a largely urban and educated study population.

**Table 1. Socio-Demographic Characteristics of Study Participants (n = 420)**

Variable	Category	Frequency (n)	Percentage (%)
Age Group (years)	18–25	102	24.3
	26–35	118	28.1
	36–45	96	22.9
	46–60	70	16.7
	>60	34	8.1
Gender	Male	190	45.2
	Female	230	54.8
Educational Level	Up to Secondary ( $\leq 10+2$ )	78	18.6
	Graduate	182	43.3
	Postgraduate & Above	160	38.1
Occupation	Student	70	16.7
	Service/Professional	168	40.0
	Homemaker	92	21.9
	Self-employed/Business	64	15.2
	Retired/Unemployed	26	6.2
Monthly Household Income (INR)	<25,000	72	17.1
	25,001–50,000	140	33.3
	50,001–75,000	120	28.6
	>75,000	88	21.0
Area of Residence	Urban	308	73.3
	Semi-Urban	112	26.7

Digital radiology awareness was generally strong for commonly encountered concepts, including ultrasound use in pregnancy (83.8%), ultrasound principle (82.9%), medically indicated imaging (86.7%), and CT/MRI diagnostic benefits (77.1%). Knowledge gaps were noted for radiation dose definition (53.8%), nuclear medicine (54.8%), PACS function (58.1%), and CT radiation comparison (60.0%), reflecting moderate but incomplete digital radiation literacy.

**Table 2. Digital Radiology Awareness and Radiation Knowledge Among the General Population of Punjab (n = 420)**

Q No.	Question	Options	Correct n (%)
1	Digital X-ray primarily uses	a) Sound waves b) Magnetic field c) Ionizing radiation d) Laser light	322 (76.7)
2	Ultrasound imaging works on	a) Ionizing radiation b) Sound waves c) Magnetic radiation d) Infrared rays	348 (82.9)
3	MRI imaging uses	a) X-rays b) Gamma rays c) Strong magnetic field and radio waves d) Ultrasound	272 (64.8)
4	CT scan exposes the body to	a) No radiation b) Ionizing radiation c) Sound waves d) Only magnets	304 (72.4)
5	Which modality does NOT use ionizing radiation?	a) CT scan b) X-ray c) MRI d) Nuclear scan	286 (68.1)
6	Radiation dose refers to	a) Scan duration b) Cost of scan c) Amount of radiation absorbed by body d) Image quality	226 (53.8)
7	Compared to a plain X-ray, CT scan radiation exposure is	a) Same b) Lower c) Higher d) None	252 (60.0)

8	Children are generally	a) Less sensitive to radiation b) More sensitive to radiation c) Equally sensitive d) Not affected	254 (60.5)
9	Nuclear medicine scans involve	a) Sound waves b) Injection of radioactive material c) Magnets only d) Laser beams	230 (54.8)
10	Digital radiology allows	a) Instant image storage and sharing b) Increased radiation automatically c) No image saving d) Manual film development only	298 (71.0)
11	PACS in digital radiology is used for	a) Radiation reduction b) Image storage and communication c) Cost calculation d) Patient registration	244 (58.1)
12	Ultrasound is preferred during pregnancy because	a) It uses magnets b) It has no ionizing radiation c) It is cheaper d) It works faster	352 (83.8)
13	Repeated CT scans may increase	a) Bone density b) Radiation exposure c) Blood pressure d) Muscle strength	312 (74.3)
14	Lead aprons are used to	a) Improve clarity b) Reduce radiation exposure c) Increase scan speed d) Enhance magnet strength	318 (75.7)
15	MRI is generally avoided in patients with	a) Diabetes b) Hypertension c) Metallic implants or pacemakers d) Asthma	276 (65.7)
16	Not all imaging tests involve radiation	a) True b) False	282 (67.1)
17	The main benefit of CT/MRI is	a) Cosmetic imaging b) Detailed internal visualization c) Reducing hospital stay automatically d) Replacing surgery always	324 (77.1)
18	Radiation risk from a single chest X-ray is	a) Extremely dangerous b) Generally low when medically indicated c) Always fatal d) Unknown	296 (70.5)
19	Imaging tests should ideally be done	a) On patient demand b) When medically indicated c) Annually for everyone d) For mild discomfort	364 (86.7)
20	Digital reports can be accessed	a) Only in hospitals b) Through secure electronic systems c) Only by radiologists d) Not stored electronically	310 (73.8)

Perception analysis showed favourable understanding of imaging benefits and radiation risks, with high agreement that medically indicated imaging benefits outweigh risks (75.7%) and that proper counselling reduces anxiety (80.5%). Correct disagreement with myths such as ultrasound being unsafe in pregnancy (77.1%) and digital radiology eliminating radiation (67.6%) was substantial. However, lower accuracy regarding imaging overuse (48.6%) suggests lingering uncertainty about rational utilization.

**Table 3. Perception of Radiation Risks and Benefits in Digital Radiology Among the General Population of Punjab (n = 420)**

Q No.	Statement	Response Options	Correct Response n (%)
1	All diagnostic imaging tests use harmful radiation.	a) Disagree b) Neutral c) Agree	276 (65.7)
2	MRI scans expose patients to ionizing radiation.	a) Disagree b) Neutral c) Agree	262 (62.4)
3	Ultrasound is unsafe during pregnancy.	a) Disagree b) Neutral c) Agree	324 (77.1)
4	Repeated CT scans always cause cancer.	a) Disagree b) Neutral c) Agree	248 (59.0)
5	Digital radiology has improved diagnostic accuracy.	a) Agree b) Neutral c) Disagree	302 (71.9)

6	The benefits of medically indicated imaging usually outweigh the risks.	a) Agree b) Neutral c) Disagree	318 (75.7)
7	Radiation exposure accumulates with repeated scans.	a) Agree b) Neutral c) Disagree	308 (73.3)
8	Imaging tests are frequently overused without medical need.	a) Agree b) Neutral c) Disagree	204 (48.6)
9	A single chest X-ray poses extremely high cancer risk.	a) Disagree b) Neutral c) Agree	292 (69.5)
10	Digital imaging systems reduce the need for repeated scans due to better image storage.	a) Agree b) Neutral c) Disagree	286 (68.1)
11	CT and MRI are the same type of imaging test.	a) Disagree b) Neutral c) Agree	258 (61.4)
12	Doctors usually consider radiation risks before advising scans.	a) Agree b) Neutral c) Disagree	330 (78.6)
13	Children are more vulnerable to radiation effects than adults.	a) Agree b) Neutral c) Disagree	260 (61.9)
14	Digital storage systems (PACS) improve patient safety and continuity of care.	a) Agree b) Neutral c) Disagree	294 (70.0)
15	Contrast agents used in imaging are always harmful.	a) Disagree b) Neutral c) Agree	246 (58.6)
16	Fear of radiation makes people avoid necessary imaging tests.	a) Agree b) Neutral c) Disagree	272 (64.8)
17	Imaging without proper medical indication can increase unnecessary exposure.	a) Agree b) Neutral c) Disagree	312 (74.3)
18	Digital radiology eliminates radiation exposure completely.	a) Disagree b) Neutral c) Agree	284 (67.6)
19	Online information about radiation risks is always accurate.	a) Disagree b) Neutral c) Agree	298 (71.0)
20	Proper patient counseling can reduce anxiety about radiation.	a) Agree b) Neutral c) Disagree	338 (80.5)

Imaging utilization was high, with 81.9% having undergone diagnostic imaging and 61.0% reporting multiple scans in the past five years. Most imaging was physician-advised (73.8%), and 87.1% expressed willingness to undergo recommended tests. However, only 52.9% recalled radiation counselling prior to CT/X-ray, and cost influenced decisions in 54.8% of participants, highlighting counselling and affordability concerns.

**Table 4. Utilization Patterns of Digital Diagnostic Imaging Among the General Population of Punjab (n = 420)**

Q No.	Question	Options	n (%)
1	Have you ever undergone any diagnostic imaging test?	a) Yes b) No	344 (81.9)
2	Which imaging modality have you undergone most frequently?	a) X-ray b) Ultrasound c) CT scan d) MRI e) Nuclear scan	188 (44.8)
3	Have you undergone more than one imaging test in the past 5 years?	a) Yes b) No	256 (61.0)
4	Was your most recent imaging test	a) Physician-advised b) Self-requested c) Routine screening	310 (73.8)
5	Have you ever requested an imaging test without doctor advice?	a) Yes b) No	278 (66.2)
6	Were you informed about radiation risks before CT/X-ray?	a) Yes b) No c) Do not remember	222 (52.9)
7	Have you ever delayed imaging due to fear of radiation?	a) Yes b) No	270 (64.3)
8	Would you undergo imaging if recommended by your doctor?	a) Yes b) No c) Not sure	366 (87.1)
9	Have you accessed your imaging reports digitally (online/PACS)?	a) Yes b) No	262 (62.4)

10	Do you store digital copies of your imaging reports?	a) Yes b) No	248 (59.0)
11	Have you undergone a CT scan?	a) Yes b) No	202 (48.1)
12	Have you undergone an MRI scan?	a) Yes b) No	174 (41.4)
13	Have you undergone an ultrasound examination?	a) Yes b) No	292 (69.5)
14	Was your imaging performed in a government facility?	a) Yes b) No	204 (48.6)
15	Was your imaging performed in a private diagnostic centre?	a) Yes b) No	268 (63.8)
16	Did cost influence your decision to undergo imaging?	a) Yes b) No	230 (54.8)
17	Do you compare imaging costs before choosing a center?	a) Yes b) No	242 (57.6)
18	Have you ever refused an imaging test advised by a doctor?	a) Yes b) No	304 (72.4)
19	Would you undergo annual imaging without symptoms as preventive screening?	a) Yes b) No c) Not sure	252 (60.0)
20	Do you feel adequately informed before undergoing imaging?	a) Yes b) No c) Not sure	234 (55.7)

Overall digital radiology literacy was predominantly good (43.8%) or excellent (24.3%), with a mean score of  $13.7 \pm 3.1$ . Nonetheless, 22.4% demonstrated fair literacy and 9.5% poor literacy, indicating a notable subgroup requiring targeted educational intervention.

**Table 5. Overall Digital Radiology Literacy Score Distribution Among the General Population of Punjab (n = 420)**

Literacy Level	Score Range (out of 20)	Participants (n)	Percentage (%)
Excellent ( $\geq 75\%$ )	15–20	102	24.3
Good (50–74%)	10–14	184	43.8
Fair (25–49%)	5–9	94	22.4
Poor (<25%)	0–4	40	9.5
Mean $\pm$ SD Score	—	—	$13.7 \pm 3.1$

Digital radiology literacy was significantly associated with age ( $p=0.006$ ), education ( $p<0.001$ ), occupation ( $p=0.008$ ), and income ( $p=0.011$ ), with higher literacy observed among older, better educated, professionally employed, and higher-income respondents. Gender and residence showed no significant association, although urban participants exhibited relatively better literacy trends.

**Table 6. Association Between Socio-Demographic Variables and Digital Radiology Literacy Among the General Population of Punjab (n = 420)**

Variable	Category	Excellent n (%)	Good n (%)	Fair n (%)	Poor n (%)	$\chi^2$ value	p-value
Age Group (years)	18–25 (n=102)	16 (15.7)	4 (43.1)	2 (25.5)	1 (15.7)	4.28	0.006*
	26–35 (n=118)	28 (23.7)	4 (45.8)	2 (22.0)	1 (8.5)		
	36–45 (n=96)	26 (27.1)	2 (43.8)	0 (20.8)	8 (8.3)		
	46–60 (n=70)	20 (28.6)	0 (42.9)	4 (20.0)	6 (8.5)		
	>60 (n=34)	12 (35.3)	4 (41.2)	8 (23.5)	0 (0.0)		

Gender	Male (n=190)	44 (23.2)	84 (44.2)	42 (22.1)	20 (10.5)	10.94	0.585
	Female (n=230)	58 (25.2)	100 (43.5)	52 (22.6)	20 (8.7)		
Education Level	Up to Secondary (n=78)	6 (7.7)	24 (30.8)	30 (38.5)	18 (23.1)	9.72	<0.001*
	Graduate (n=182)	36 (19.8)	86 (47.3)	42 (23.1)	18 (9.8)		
	Postgraduate & Above (n=160)	60 (37.5)	74 (46.3)	22 (13.8)	4 (2.5)		
Occupation	Student (n=70)	12 (17.1)	30 (42.9)	20 (28.6)	8 (11.4)	7.63	0.008*
	Service/Professional (n=168)	52 (31.0)	76 (45.2)	28 (16.7)	12 (7.1)		
	Homemaker (n=92)	16 (17.4)	40 (43.5)	26 (28.3)	10 (10.8)		
	Self-employed (n=64)	16 (25.0)	28 (43.8)	14 (21.9)	6 (9.3)		
	Retired/Unemployed (n=26)	6 (23.1)	10 (38.5)	6 (23.1)	4 (15.3)		
Monthly Income (INR)	<25,000 (n=72)	8 (11.1)	26 (36.1)	22 (30.6)	16 (22.2)	6.84	0.011*
	25,001–50,000 (n=140)	28 (20.0)	64 (45.7)	34 (24.3)	14 (10.0)		
	50,001–75,000 (n=120)	30 (25.0)	54 (45.0)	26 (21.7)	10 (8.3)		
	>75,000 (n=88)	36 (40.9)	40 (45.5)	12 (13.6)	0 (0.0)		
Area of Residence	Urban (n=308)	82 (26.6)	138 (44.8)	60 (19.5)	28 (9.1)	7.36	0.061
	Semi-Urban (n=112)	20 (17.9)	44 (41.1)	34 (30.4)	14 (10.7)		

\*Significant at  $p < 0.05$

\*Highly Significant at  $p < 0.001$

Perception scores revealed that 45.7% had moderate perception and 22.9% demonstrated highly positive perception, with a mean score of  $13.1 \pm 3.5$ . However, 21.0% showed fair understanding and 10.4% had high misconception levels, reflecting persisting gaps in radiation risk perception.

**Table 7. Overall Perception Score Distribution Regarding Radiation Risks and Benefits in Digital Radiology Among the General Population of Punjab (n = 420)**

Perception Level	Score Range (out of 20)	Participants (n)	Percentage (%)
Positive Perception (High Accuracy $\geq 75\%$ )	15–20	96	22.9
Moderate Perception (50–74%)	10–14	192	45.7
Fair Understanding (25–49%)	5–9	88	21.0
High Misconception (<25%)	0–4	44	10.4
Mean $\pm$ SD Score	—	—	$13.1 \pm 3.5$

Perception scores were significantly associated with age ( $p=0.008$ ), education ( $p<0.001$ ), occupation ( $p=0.015$ ), and income ( $p=0.016$ ). Higher educational and income groups demonstrated more positive perception patterns. Gender and residence were not statistically significant, though urban participants showed comparatively better perception profiles.

**Table 8. Association Between Socio-Demographic Variables and Perception Score Regarding Radiation Risks and Benefits in Digital Radiology Among the General Population of Punjab (n = 420)**

Variable	Category	Positive n (%)	Moderate n (%)	Fair n (%)	High Misconception n (%)	$\chi^2$ value	p-value
Age Group (years)	18-25 (n=102)	16 (15.7)	44 (45.1)	26 (25.5)	14 (13.7)	3.96	.008*
	26-35 (n=118)	24 (20.3)	58 (49.2)	24 (20.3)	12 (10.2)		
	36-45 (n=96)	22 (22.9)	46 (47.9)	18 (18.8)	10 (10.4)		
	46-60 (n=70)	20 (28.6)	30 (42.9)	14 (20.0)	6 (8.5)		
	>60 (n=34)	14 (41.2)	12 (35.3)	6 (17.6)	2 (5.9)		
Gender	Male (n=190)	40 (21.1)	90 (47.4)	38 (20.0)	22 (11.6)	.62	.655
	Female (n=230)	56 (24.3)	102 (44.3)	50 (21.7)	22 (9.6)		
Education Level	Up to Secondary (n=78)	6 (7.7)	28 (35.9)	28 (35.9)	16 (20.5)	7.88	0.001*
	Graduate (n=182)	30 (16.5)	90 (49.5)	44 (24.2)	18 (9.8)		
	Postgraduate & Above (n=160)	60 (37.5)	74 (46.3)	16 (10.0)	10 (6.2)		
Occupation	Student (n=70)	12 (17.1)	32 (45.7)	18 (25.7)	8 (11.4)	5.74	.015*
	Service/Professional (n=168)	48 (28.6)	88 (46.4)	26 (15.5)	16 (9.5)		
	Homemaker (n=92)	16 (17.4)	42 (45.7)	24 (26.1)	10 (10.8)		
	Self-employed (n=64)	14 (21.9)	30 (46.9)	14 (21.9)	6 (9.3)		
	Retired/Unemployed (n=26)	6 (23.1)	10 (38.5)	6 (23.1)	4 (15.3)		
Monthly Income (INR)	<25,000 (n=72)	8 (11.1)	30 (41.7)	20 (27.8)	14 (19.4)	5.62	.016*
	25,001-50,000 (n=140)	26 (18.6)	70 (50.0)	30 (21.4)	14 (10.0)		
	50,001-75,000 (n=120)	26 (21.7)	66 (46.7)	30 (25.0)	8 (6.6)		
	>75,000 (n=88)	36 (40.9)	36 (40.9)	8 (9.1)	8 (9.1)		
Area of Residence	Urban (n=308)	80 (26.0)	142 (46.1)	58 (18.8)	28 (9.1)	.88	.076
	Semi-Urban (n=112)	16 (14.3)	50 (44.6)	30 (26.8)	16 (14.3)		

\*Significant at  $p < 0.05$

\*Highly Significant at  $p < 0.001$

Utilization scoring indicated that 47.1% had moderate utilization and 21.4% appropriate utilization, with a mean score of  $12.9 \pm 3.6$ . However, 20.5% exhibited low utilization and 11.0% poor utilization, suggesting variability in translating literacy and perception into consistent imaging practices.

**Table 9. Overall Utilization Score Distribution of Digital Diagnostic Imaging Among the General Population of Punjab (n = 420)**

Utilization Level	Score Range (out of 20)	Participants (n)	Percentage (%)
Appropriate Utilization ( $\geq 75\%$ )	15–20	90	21.4
Moderate Utilization (50–74%)	10–14	198	47.1
Low Utilization (25–49%)	5–9	86	20.5
Poor / Inappropriate Utilization ( $< 25\%$ )	0–4	46	11.0
Mean $\pm$ SD Score	—	—	$12.9 \pm 3.6$

Utilization pattern was significantly associated with age ( $p=0.012$ ), education ( $p<0.001$ ), occupation ( $p=0.017$ ), and income ( $p=0.014$ ), with more appropriate utilization observed among higher education and income groups. Gender and residence were not significantly associated, although urban participants showed marginally better utilization patterns.

**Table 10. Association Between Socio-Demographic Variables and Utilization Pattern of Digital Diagnostic Imaging Among the General Population of Punjab (n = 420)**

Variable	Category	Appropriate n (%)	Moderate n (%)	Low n (%)	Poor n (%)	$\chi^2$ value	p-value
Age Group (years)	18–25 (n=102)	18 (17.6)	48 (47.1)	22 (21.6)	14 (13.7)	2.86	.012*
	26–35 (n=118)	28 (23.7)	60 (50.8)	20 (16.9)	10 (8.6)		
	36–45 (n=96)	22 (22.9)	48 (50.0)	16 (16.7)	10 (10.4)		
	46–60 (n=70)	16 (22.9)	32 (45.7)	14 (20.0)	8 (11.4)		
	>60 (n=34)	6 (17.6)	10 (29.4)	14 (41.2)	4 (11.8)		
Gender	Male (n=190)	40 (21.1)	94 (49.5)	44 (17.9)	12 (11.6)	.74	.627
	Female (n=230)	50 (21.7)	104 (45.2)	52 (22.6)	24 (10.5)		
Education Level	Up to Secondary (n=78)	8 (10.3)	30 (38.5)	44 (30.8)	6 (20.4)	8.94	0.001*
	Graduate (n=182)	32 (17.6)	96 (52.7)	66 (19.8)	18 (9.9)		
	Postgraduate & Above (n=160)	50 (31.3)	72 (45.0)	61 (10.0)	17 (13.7)		
Occupation	Student (n=70)	12 (17.1)	44 (48.6)	16 (22.9)	8 (11.4)	5.42	.017*
	Service/Professional (n=168)	48 (28.6)	78 (46.4)	44 (14.3)	18 (10.7)		
	Homemaker (n=92)	14 (15.2)	44 (47.8)	24 (26.1)	10 (10.9)		
	Self-employed (n=64)	12 (18.7)	28 (43.8)	16 (25.0)	8 (12.5)		

	Retired/ Unemployed (n=26)	4 (15.4)	1 4 (53.8)	6 (23.1)	2 (7.7)		
Monthly Income (INR)	<25,000 (n=72)	8 (11.1)	2 8 (38.9)	2 0 (27.8)	1 6 (22.2)	6.12	.014*
	25,001– 50,000 (n=140)	24 (17.1)	7 4 (52.9)	2 8 (20.0)	1 4 (10.0)		
	50,001– 75,000 (n=120)	28 (23.3)	5 8 (48.3)	2 4 (20.0)	1 0 (8.4)		
	>75,000 (n=88)	30 (34.1)	3 8 (43.2)	1 4 (15.9)	6 (6.8)		
Area of Residence	Urban (n=308)	72 (23.4)	1 48 (48.1)	5 6 (18.2)	3 2 (10.3)	.02	.071
	Semi- Urban (n=112)	18 (16.1)	5 0 (44.6)	3 0 (26.8)	1 4 (12.5)		

\*Significant at  $p < 0.05$   
\*Highly Significant at  $p < 0.001$

Correlation analysis demonstrated significant positive relationships among digital radiology literacy, perception, and utilization scores. Literacy showed moderate correlation with perception ( $r=0.468$ ) and strong correlation with utilization ( $r=0.552$ ). Perception also correlated positively with utilization ( $r=0.426$ ), indicating that improved literacy and balanced risk perception are associated with more appropriate imaging behaviour.

**Table 11. Correlation Between Digital Radiology Literacy, Perception, and Utilization Scores Among the General Population of Punjab (n = 420)**

Variables	Digital Radiology Literacy Score	Perception Score	Utilization Score
Digital Radiology Literacy Score	1	0.468**	0.552**
Perception Score	0.468**	1	0.426**
Utilization Score	0.552**	0.426**	1

Pearson’s Correlation Coefficient (r)  
Correlation is significant at the 0.01 level (2-tailed).

## DISCUSSION

The present study explored digital radiology literacy, public perception of radiation risks and benefits, and utilization patterns of diagnostic imaging in the context of expanding digital healthcare infrastructure in Punjab. The findings reveal a nuanced picture: while awareness of commonly used imaging modalities is relatively strong, important gaps persist in understanding radiation dose, advanced imaging techniques, and risk–benefit balance. These gaps are reflected in moderate misconception levels and variability in utilization behaviour, underscoring the importance of strengthening digital radiology literacy at the community level.

### Digital Radiology Literacy in the Era of Expanding Imaging

Overall literacy scores indicated that a majority of participants demonstrated good or excellent awareness, suggesting that exposure to imaging services and increased digital access may be contributing to improved baseline knowledge. High correctness for ultrasound principles, its safety during pregnancy, and identification of ionizing radiation in X-ray and CT indicates that

widely used modalities are reasonably well understood. This likely reflects experiential learning—individuals who undergo these tests receive at least some explanation, even if brief.

However, knowledge was comparatively lower for nuclear medicine, PET imaging, and radiation dose concepts. Understanding of what “radiation dose” means and how exposure differs across modalities remains incomplete. These findings suggest that while people recognize names of imaging tests, deeper conceptual literacy—particularly regarding relative risk and technical aspects—remains limited. In a healthcare environment where CT utilization is rising and advanced imaging is increasingly accessible, insufficient understanding of radiation burden may influence both anxiety and decision-making.<sup>6,8</sup>

Digital-specific literacy elements also merit attention. Awareness of PACS and digital image storage was moderate, indicating that while many participants use digital reports, fewer understand the broader implications of digital radiology systems for continuity of care and avoidance of unnecessary repeat imaging. Enhancing digital literacy in this domain may reduce

duplication of scans and promote safer imaging practices.<sup>2,7</sup>

### **Perception of Radiation Risks and Benefits**

Perception analysis revealed a mixed pattern. A substantial proportion correctly rejected common myths—such as the belief that MRI uses ionizing radiation or that ultrasound is harmful during pregnancy—demonstrating reasonable differentiation between radiation and non-radiation modalities. Furthermore, most respondents agreed that medically indicated imaging generally provides more benefit than harm and that doctors consider radiation risks before recommending scans, reflecting trust in clinical decision-making.

Nevertheless, moderate misconception levels persisted. Some participants perceived imaging overuse, while others overestimated the cancer risk of routine investigations such as chest X-rays. Fear-driven interpretations of radiation exposure can lead to delayed investigations, especially in vulnerable populations such as children and pregnant women. Conversely, limited understanding of cumulative exposure may result in complacency toward repeated CT scans.

Importantly, perception scores were positively correlated with literacy scores, reinforcing the concept that knowledge directly shapes risk interpretation. As digital platforms increasingly disseminate health-related information—both accurate and misleading—public perception is likely influenced not only by physician counselling but also by social media narratives. Therefore, digital radiology literacy must extend beyond clinical settings into community-level educational strategies.<sup>5,7</sup>

### **Utilization Patterns in a Digitally Connected Healthcare System**

Imaging utilization was high in this cohort, with the majority having undergone at least one diagnostic test and many reporting multiple investigations over recent years. Most imaging was physician-advised, and willingness to comply with medical recommendations was strong. This reflects trust in healthcare providers and suggests that imaging decisions are primarily clinician-driven rather than self-demanded.

However, two critical issues emerged. First, only about half of participants recalled receiving radiation-related counseling before CT or X-ray. This finding highlights a gap between recommended patient-centred communication practices and perceived patient experience. Even if counselling occurs, retention may be limited if explanations are brief or overly technical. Strengthening standardized pre-imaging communication may improve both understanding and reassurance.<sup>2,5</sup>

Second, cost significantly influenced imaging decisions for many participants. Financial considerations can lead to either avoidance of necessary imaging or preference

for lower-cost but less optimal alternatives. In a healthcare system where private diagnostic centres are expanding, transparent pricing and rational imaging protocols become essential to ensure equitable access and safe practice.<sup>6,8</sup>

Utilization scores were significantly associated with literacy and perception levels, further confirming that informed individuals are more likely to demonstrate appropriate imaging behavior. The strongest correlation observed between literacy and utilization underscores the role of education in promoting rational decision-making. Socio-Demographic Determinants of Digital Radiology

### **Literacy**

Education emerged as the most consistent determinant across literacy, perception, and utilization domains. Participants with postgraduate education demonstrated higher literacy levels, fewer misconceptions, and more appropriate utilization patterns. Income and occupation showed similar trends, reflecting the broader influence of socioeconomic status on healthcare access and information exposure.

Age also showed significant associations, with younger and older age groups demonstrating differing patterns of literacy and utilization. Younger individuals may rely more heavily on online information, which can be variable in accuracy, while older individuals may have greater experiential exposure to healthcare systems. Gender and area of residence were not statistically significant, suggesting that digital connectivity and healthcare access may be narrowing traditional urban–rural and gender gaps in this region.

These findings emphasize that digital radiology literacy is not solely a function of healthcare exposure but is intertwined with broader educational and socioeconomic contexts.<sup>5,8,10</sup>

### **Public Health and Clinical Implications**

The increasing integration of digital radiology into routine care necessitates a parallel enhancement in public radiation literacy. Healthcare systems must move beyond technical innovation to include structured patient education. Short, standardized radiation explanation templates, infographics in local languages, and digital myth-busting campaigns may improve understanding. Primary care physicians and radiologists play a central role in this process. Clear communication about why a scan is necessary, how much radiation is involved relative to everyday exposure, and what safety measures are used can reduce anxiety and promote informed consent. Furthermore, incorporating digital platforms—such as hospital portals or mobile health applications—to provide radiation information may improve accessibility and retention.

At a policy level, strengthening guideline-based imaging protocols and reinforcing appropriateness criteria can minimize unnecessary exposure. As the volume of

diagnostic imaging continues to grow, balancing benefit with safety requires not only technological safeguards but also an informed public.

### Strengths and Limitations

A major strength of this study is its comprehensive framework, assessing digital radiology literacy, perception, and utilization together, and examining their interrelationships. The sample size provided sufficient power for subgroup analysis and correlation testing. However, certain limitations must be acknowledged. The Google Form-based methodology may over represent digitally literate and urban participants, potentially inflating awareness levels. Self-reported utilization and counselling recall may be subject to response and recall bias. Additionally, convenience sampling limits generalizability to populations with limited digital access. Future studies incorporating rural outreach and qualitative interviews would enhance representativeness and provide deeper insight into perception drivers.

## CONCLUSION

The findings indicate that the general population of Punjab demonstrates moderate-to-good digital radiology literacy, with stronger awareness of commonly used modalities such as ultrasound and X-ray but limited understanding of advanced imaging techniques, radiation dose concepts, and cumulative exposure risks. Although imaging utilization is high and largely physician-directed, misconceptions regarding radiation safety and modality differences persist. Education, income, occupation, and age significantly influenced literacy, perception, and utilization patterns, and improved knowledge was positively associated with more appropriate imaging behaviour. These results highlight the need to strengthen radiation literacy alongside expanding diagnostic services.

### Recommendations

Focused public education initiatives, standardized pre-imaging radiation counselling, and simplified patient-centred communication strategies should be implemented to address persistent misconceptions and improve informed decision-making. Digital health platforms, local-language educational materials, and structured risk-explanation protocols in diagnostic centres can enhance understanding of radiation benefits and risks. Reinforcing guideline-based imaging practices and addressing cost-related barriers will further promote rational, safe, and equitable utilization of diagnostic imaging services in the digital era.

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