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RESEARCH ARTICLE

Current Trends in Teleradiology Utilization Patterns in India, Including Perceptions and Attitudes- A Nationwide Survey of Indian Radiologists

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ABSTRACT

Purpose: To provide an overview of teleradiology utilization patterns in India, including the current trends, perceptions and attitudes by conducting a nationwide survey among Indian Radiologists.

Methods: An online nationwide survey of Indian radiologists working in varied practice settings was conducted with a questionnaire via email. A descriptive analysis of the data was performed, and the results were summarized.

Results: The survey was completed by 309 radiology professionals (response rate 3%). The significant majority reported utilizing or practicing teleradiology. A large fraction of participants reported using a dedicated teleradiology workflow. However, the use of portable devices, such as laptops, to read images was also reported. Teleradiology was reported to be used in a variety of clinical scenarios, including emergency and after-hours coverage as well as routine reporting. The majority of survey respondents were in an urban location. Teleradiology was expected to increase utilization, reach, and sustainability of radiology services, with reduced turnaround time, reduced cost, improved workload distribution, perception of improved work-life balance, improved radiology support for referring physicians and improved service enumerated as the benefits. Interestingly, a slight majority felt that teleradiology may not be an asset for the key stakeholders, i.e., the radiologist, the referring physician and the patient, but instead a liability. Concerns of greater pressure to perform better at a lower fee as a teleradiologist, commoditization of radiology by price undercutting, disruption of relationship with physicians and patients and lack of accountability were expressed.

Conclusion: This survey provides insight into the utilization patterns of teleradiology in India its impact on healthcare, and highlights the perceptions and attitudes of Indian Radiologists towards this practice model. While teleradiology is widely utilized with an overall positive attitude, concerns remain that need to be addressed.

Keywords: Teleradiology, Radiologists, Survey, Questionnaire.

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INTRODUCTION

Teleradiology is a subset of telemedicine that involves transmitting radiological images such as digitized X-rays, CT, MRI, ultrasound, and nuclear medicine studies from one location to another for interpretation and consultation.[1] With wide penetration of the internet, universal adoption of the DICOM image standard, PACS and good computers at affordable costs, teleradiology has now become an integral part of a majority of radiology practices worldwide in the setting of radiologist shortages.[2,3] While teleradiology became an established paradigm in the United States in the late 90's and the first decade of the new mi90'snium (5), adoption and utilization has been much slower in the developing world. In India, the earliest attempt at teleradiology reporting dates to

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Fig. 1: Screenshot of the desktop view of the survey

year 1996 by a private Imaging Center in Mumbai. The first teleradiology company in India was set up in 2002 with its headquarters in Bangalore (6). Studies evaluating the technical and clinical feasibility of cross-border teleradiology were done at the beginning of this century (7, 8). Since then, a few teleradiology centers in India started reporting of offshore scans from the US, Singapore, Africa, the Middle East and Europe with high levels of accuracy and quick turnaround time (9, 10, 11). The positive impact of teleradiology on patient care has been well documented by numerous studies (12, 13, 14, 15, 16,17).

India has approximately 20,000 radiologists for a population of 1.4 billion people. This translates to an unacceptably low ratio of one radiologist for every 1,00,000 individuals, much lower than the World Healthcare Organisation standard (16). Teleradiology can supplement and support the on-site radiology workforce and make radiologists accessible to areas that lack any such as rural and remote regions (17). Teleradiology was in the limelight during the COVID-19 pandemic by assuring radiologist availability and accessibility, while maintaining social distancing (18,19). While a growth rate (CAGR) of 15.57% is projected during 2024 - 2032 (20), we wanted to see the radiologists' perspectives and attituderadiologists's changing landscape of radiology practice and provide directions for better and more effective practice models.

This study aims to conduct a nationwide survey of Indian radiologists from varied practice settings to understand the demand, gaps and variations in teleradiology utilization. The survey questionnaire also aims to understand their perceptions of the impact of teleradiology on their practice in terms of personal, professional and clinical satisfaction.

MATERIALS AND METHODS

A teleradiology utilization survey was designed by full-time teleradiologists and fine-tuned after inputs from an expert panel of radiologists from diverse settings including academia and private practice. The survey questionnaire was created using the web-based application questionpro.com (21) (Fig. 1). It consists of 23 questions divided into 5 sections consisting of 12 single response and 11 multiple response questions (Table 1).

In the first section, the basic demographic information about the radiologists, such as age, gender, marital status, professional experience and their geographic location in India, is collected. The second section covers information regarding the site and size of their practice, academic background and professional position. In the third section, the questions are specifically focused on teleradiology utilization and user dimension of teleradiology services. The questions regarding the technology usage for tele-reporting are designed in the fourth section. The last section comprised of questions pertaining to potential advantages, risks and perceptions of teleradiology among the radiologists.

In addition to the specific questions, the survey also includes sections of free text for comments from the participants. The quantitative and statistical analysis of the data would be carried out to determine the results. Further, interpretation of the results was done to determine the trends in teleradiology utilization patterns in India.

Study population

This is a nationwide survey of radiologists residing and practicing all across India in different institutions, government and private hospitals and diagnostic centers.

Survey distribution

An online questionnaire was designed and an email invitation with a URL link was sent to the participants to fill in their responses through any internet browser. Each participant could access and attempt the survey only once within the study period of 2 months. Weekly reminders were sent to the participants after the launch of the survey, and 48 hours before the closure of the survey. Institutional review board approval was taken. No ethical approval was required for this voluntary and anonymous online survey of radiologists.

RESULTS

A total of 309 respondents completed the survey out of 10,000 participants (response rate 3%) over a 10-week study period from 4th August 2023 to 15th October 2023. All responses were anonymous. The survey questionnaire along with their responses, are presented in Table 2.

Demographics

In our survey, three-quarters of the respondents (n=233/309, 75%) belonged to the age group 31-50 years, followed by 13% (n=39/309) belonged to the age group 51-65 years, 10% (n=31/309) under 30years and only 2% (n=6/309) were above 65 years in age (Fig. 2).

Out of the total 309 participants, 70.55% (n= 218/309) were male, 29.13% (n= 90/309) were female and 1 preferred not to disclose. Most participants were married (n=260/309, 84%).

Forty percent of participants had been practicing radiology for 5 to 15 years (n=124/309). An equal percentage (28%) of

Table 1: Subject categories of the questions in the survey

S. No.	*Question categories*
1	Demographics
2	Teleradiology practice set-up
3	Teleradiology utilization
4	Technology utilization
5	Attitudes and perceptions

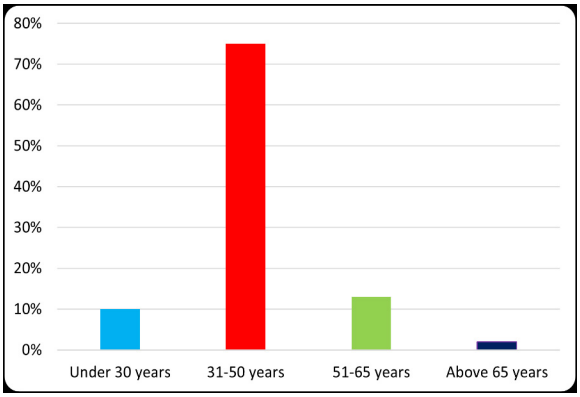

Fig. 2: Distribution of participants based on age

participants had experience of 1 to 5 years (n=86/309) and more than 15 years (85/309) in this field. Only 4% (n=14/309) of the participating radiologists were freshers having less than one year of radiology practice (Table 2).

Radiologists from all over India participated in the survey (Fig. 3). The maximum participants were from Karnataka (n=66/309, 21%), Telangana (n=47/309, 15%) and Andhra Pradesh (n=30/309, 10%), while there were also participants from North- Eastern states (n=2/309) and Union Territories (n=7/309).

Teleradiology Practice Set-up

A multivariable analysis was carried out among the participating radiologists, considering practice setting, group practice size, professional positions, academic background, and practice location. The sites of the main professional activities of the respondents were diagnostic centre (a single center or multicentre practice) (n= 130/433, 30%), followed by academic private or government hospital (n=118/433, 27%), and non-academic private or government hospital (n=84/433, 20%). Seven percent (n= 31/433) of participants practised exclusively teleradiology (Table 2).

About one -third of the respondents (n=105/309, 34%) work in a setting with a practice size of 2-5 radiologists, 28% (n=86/309) have a solo practice, 17% (n=52/309) practice in a small group of 5-10 radiologists followed by 14% (n=43/309) in a large group with more than 20 radiologists and, only 7% (n=23/309) work in a mid-sized group comprised of 10-20 radiologists.

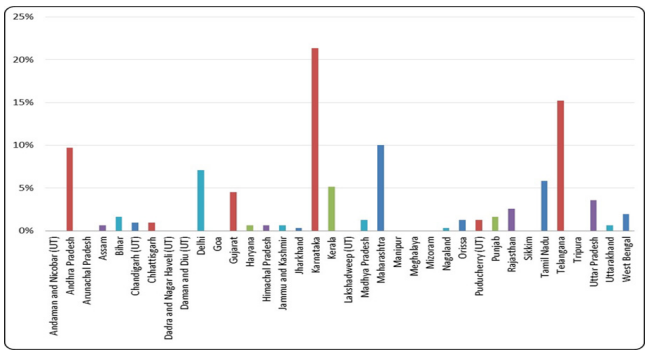

Fig. 3: Distribution of radiologists practicing in India

Regarding the professional positions of the participants, fifty percent of the participants (n=156/309) work as consultant radiologists in an organization, 21% (n=65/309) are self-employed, while others are in academics as professors or head of departments (n=26/309, 9%) or as other faculty members (n=36/309, 12%) or radiology resident /post-graduate (n=7/309, 2%). Six percent (n=19/309) of participants work in a managerial position (Radiology Director).

A multiple responses question was asked to determine the academic background of the participants. Most respondents hold MD degree (n=211/467, 45%), 25% (n=119/467) had done DNB, 11% (n=52/467) had DMRD, 9% (n=42/467) had FRCR degree, 9% (n=40/467) had done DM / PhD /Fellowship. 1% of respondents (n=3/467) are American Board-Certified radiologists.

The majority of the participants (n=305/309, 99%) practice in urban areas, including 52% working in tier 1 city and 38% in tier 2 city, 9% in small towns and only a few (n=4/309, 1%) practices in rural areas (Fig. 4).

Teleradiology Utilization

The current usage forms of teleradiology are summarized in Table 2. A large majority of the participating radiologists (n= 230/309, 74%) affirmed that they are utilizing teleradiology. Out of these, 54% (n=125/230) of radiologists use it at home, 30% (n=70/230) within a hospital or imaging centre to connect to another center, 23% (n=54/230) utilize teleradiology everywhere using a mobile device/laptop (14.36%) and 21% (n=48/230) for internal office-based teleradiology practice. Twenty six percent of the total participating radiologists (n=79/309) reported that they do not use teleradiology.

Although, the fraction of the participating teleradiologists that utilize teleradiology for reporting all the modalities in combination is 61% (n=141/230); 63% (n=145/230) radiologists used it primarily for reporting CT cases, followed by 51% (n=118/230) who used it for MRI reporting and 30% (n=70/230) for reporting X-rays.

Further, it appears that the participants utilized teleradiology equally for night-time reporting (including emergency calls) (n=130/230, 57%), and for routine cases (n=131/230, 57%), while a small number of participants (n=14/230, 6%) utilized teleradiology for reporting during their vacation times.

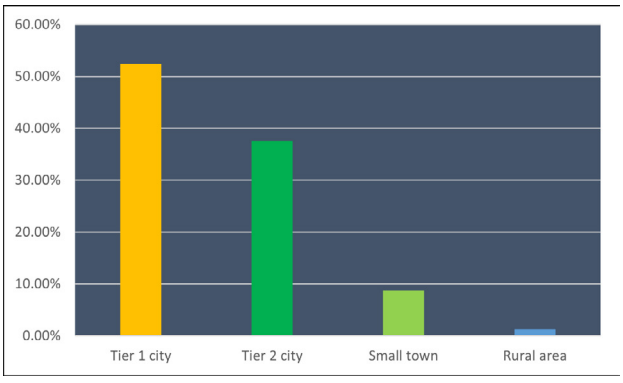

Fig. 4: Primary Practice location of Indian Radiologists

Table 2: Survey questionnaire with responses from the participants

Questions	*Responses*	*Number of respondents*	
Demographics		*n*	%
What age group do you belong to? (single response question)	Under 30 years	31	10%
	31-50 years	233	75%
	51-65 years	39	13%
	Above 65 years	6	2%
	Total number of responses	309	100%
What is your gender? (single response question)	Female	90	29.13%
	Male	218	70.55%
	Others	1	0.32%
	Total number of responses	309	100%
What is your marital status? (single response question)	Married	260	84%
	Single	49	16%
	Total number of responses	309	100%
Number of years in radiology practice. (single response question)	< 1 year	14	4%
	1-5 years	86	28%
	5-15 years	124	40%
	15 years	85	28%
	Total number of responses	309	100%
Where do you live in India? (single response question)	Fig. 3		
Teleradiology practice set-up			
What is the site of your main professional activity? (multiple responses question)	Academics and research govt hospital	44	10%
	Academics and research private hospital	74	17%
	Non-academic government hospital	12	3%
	Non-academic private hospital	72	17%
	Diagnostic centre (single center practice)	77	18%
	Diagnostic center (multicentre practice)	53	12%
	Teleradiology practice	101	23%
	Total number of responses	433	100%
Practice size (number of associated radiologists) (single response question)	Solo	86	28%
	2–5	105	34%
	5–10	52	17%
	10–20	23	7%
	Greater than 20	43	14%
	Total number of responses	309	100%
What is your professional position? (single response question)	Radiology resident/postgraduate	7	2%
	Consultant Radiologist self employed	65	21%
	Consultant Radiologist employed by an organization	156	50%
	Radiologist with managerial position (Radiology Director)	19	6 %
	Academic Faculty (up to Additional Professor)	36	12%
	Professor/HOD	26	9%
	Total number of responses	309	100%
Academic background (multiple responses question)	MD	211	45%
	DNB	119	25%
	DMRD	52	11%
	DM / PhD /Fellowship	40	9%
	FRCR	42	9%
	ABR	3	1%
	Total number of responses	467	100%
Primary Practice Location (single response question)	Tier 1 city	162	52%
	Tier 2 city	116	38%
	Small town	27	9%
	Rural area	4	1%
	Total number of responses	309	100%

Cont...

Teleradiology utilization			
Do you use teleradiology? (Choice of location) (multiple responses question)	I don't use teleradiology All others Withdon'tspital or imaging center to connect to other center At home Everywhere using a mobile device/laptop Office-based Teleradiology Practice (internal) Total number of users of teleradiology	79 (309-79) =230 70/230 125/230 54/230 48/230 230	26% (79/309) 74% (230/309) 30% 54% 23% 21%
For which modalities do you primarily use teleradiology? (multiple responses question)	X-ray reporting CT reporting MRI reporting All of the above in combination Not applicable/ others Total number of users of teleradiology	70/230 145/230 118/230 141/230 67/230 230	30% 63% 51% 61% 29%
When do you use teleradiology? (multiple responses question)	For night and weekend coverage For emergency calls On vacation All the time (for routine case reporting) Not applicable /others Total number of users of teleradiology	78/230 52/230 14/230 131/230 84/230 230	34% 23% 6% 57% 37%
What is the approximate number of cases per month reported by you using teleradiology? (single response question)	Less than 100 100 - 500 (5 - 20 cases /day) 500 - 1000 (about 30 - 40 cases/day) More than 1000 (> 40 cases per day) Not applicable (do not use teleradiology) Total number of users of teleradiology	62/230 103/230 31/230 33/230 81/309 230	27% 45% 13% 14% 26%
What is the reason for using teleradiology? (multiple responses question)	To even out workload distribution within a group/ staffing issues For second and subspecialist opinions During the Covid pandemic for reporting of Chest X-rays and CTs For insourcing from Hospitals/Diagnostic Centers For outsourcing to a Teleradiology provider Economics Not applicable / other reasons Total number of users of teleradiology	54/230 50/230 27/230 68/230 26/230 86/230 107/230 230	23% 22% 12% 30% 11% 37% 46%
Technology utilization			
Do you have a PACS/RIS system in your institute or hospital to store radiological images? (single response question)	Yes No Total number of responses	218 91 309	71% 29% 100%
For image analysis do you use (single response question)	Freeware (such as Osirix) Dial-in to Hospital PACS (such as GE) Dedicated Teleradiology Workflow Other Total number of responses	83 53 142 31 309	27% 17% 46% 10% 100%
Do you generate reports using (multiple responses question)	Handwritten on paper Dictated to transcriptionist Voice recognition Typed by yourself using shortcuts Smart reporting tools Other Total number of responses	16 89 109 160 34 9 417	4% 21% 26% 38% 8% 2% 100%
Do you use digital signature at your site of profession? (single response question)	Yes No Total number of responses	215 94 309	70% 30% 100%

Table 3: Opinions regarding the potential advantages or impacts of teleradiology (multiple responses question)*

Answer options	*Strongly agree*	*Agree*	*Neutral*	*Disagree*	*Strongly disagree*	*Total*
Better workload distribution	24%	**32%**	26%	10%	8%	100%
Better support for referring physicians	17%	**33%**	28%	14%	8%	100%
Possibility to discuss cases in a collaborative network	18%	**31%**	24%	16%	11%	100%
Reduce the diagnostic error rate	9%	23%	**31%**	23%	14%	100%
Lower the cost of reporting	28%	**38%**	17%	8%	9%	100%
Shorten the waiting hours and turn-around-time for reports	23%	**51%**	17%	5%	4%	100%
Decreased radiologist attrition rate	14%	**34%**	29%	15%	8%	100%
Improved work-life balance	16%	**34%**	19%	21%	10%	100%
Improved the overall service as perceived by referring doctors, hospital administration and patients	11%	**38%**	26%	14%	11%	100%

*The total responses across all respondents for each question and level of agreement are provided. Respondents chose an opinion that was complementary to the following question: What do you feel are the potential advantages or impacts of teleradiology? (the highest percentages are in bold)

The survey also revealed that 45% (n=103/230) of participant radiologists utilized teleradiology to report 100 to 500 studies per month, followed by 27% (n=62/230) who reported less than 100 studies per month while an equal fraction of participants teleported more than 1000 per month (>40 cases per day) (n=33/230, 14%) and 500 to 1000 (about 30 to 40 cases/day) (n=31/230, 14%).

The most frequent reason reported for using teleradiology is favorable economics (n=86/230, 37%) followed by for insourcing images from hospitals/diagnostic centers (n=68/230, 30%), optimizing workload distribution within a group and overcoming staffing issues (n=54/230, 23%), and for second and subspecialist opinions (n=50/230, 22%). 12% (n=27/230) of the participants relied on teleradiology during the Covid pandemic for reporting of Chest X-rays and CTs and 11% (n=26/230) for outsourcing imaging to a Teleradiology service provider.

Technology Utilization

About three-quarters of participants (n=218/309) confirmed using PACS/RIS system in their institute or hospital to store and archive radiological images.

For image analysis, the majority of the respondents (n=142/309, 46%) have a dedicated teleradiology workflow, while 27% of participants prefer to use freeware such as Osirix (n=83/309,) or dial-in to hospital PACS (n=53/309, 17 %). However, a smaller number of participants (n=31/309, 10%) reported using other software such as Medsynapse, Saince, RadiAnt DICOM viewer, NeoRad etc.

For report preparation, 38% (n=160/417) participating radiologists preferred self-typing the reports using shortcuts, followed by 26% (n=109/417) who use voice recognition, 21% (n=89/417) dictate to a transcriptionist and 8% (n=34/417) use smart reporting tools. 4% (n=16/417) prefer reports to be handwritten. A small number of participants (n=9/417, 2%) used telephonic notification for urgent findings.

The majority of the respondents (n=215/309, 70%) use digital signatures for the reports (Table 2).

Attitudes and perceptions

The potential advantages of teleradiology

The survey question regarding the potential advantages or impacts of teleradiology was asked. More than one answer could be given with different levels of agreement/ disagreement for the question. Table 3 summarises the radiologists' opinions regarding the poradiologists'tages of teleradiology in general. A majority agree/ strongly agree that the reduction in the wait time and turn-around-time for reports (n=228/309, 74%) is the primary advantage of teleradiology, followed by the potential to reduce the cost of reporting (n=205/309, 66%) and the ability to efficiently distribute the workload (n=174/309, 56%). Additionally, the participants also acknowledged additional positive benefits of teleradiology in the form of improvement in work-life balance (n=155/309, 50%), greater availability of radiologists for referring physicians (n=154/309, 50%), collaborative working (n=151/309, 49%), improvement in overall service (n=151/309, 49%), decrease in radiologist attrition rate (n=147/309, 47%) and reduction in the diagnostic error rate (n=100/309, 32%).

The perception of teleradiology in the radiology profession

The perception of teleradiology among radiology professionals is drafted in Fig. 5. The participating radiologists opined that teleradiology may pressurize them to perform better at a lower fee (n=253/309, 82%). However, they also agreed/ and strongly perceived teleradiology to be a technology that will increase the utilization and reach of radiology services (n=231/309, 75%), help in the sustainability of radiology practices (n=176/309, 57%) and enhance the learning opportunities for the radiologists (n=170/309, 55 %). However, participants also feared a higher likelihood of having medicolegal issues with

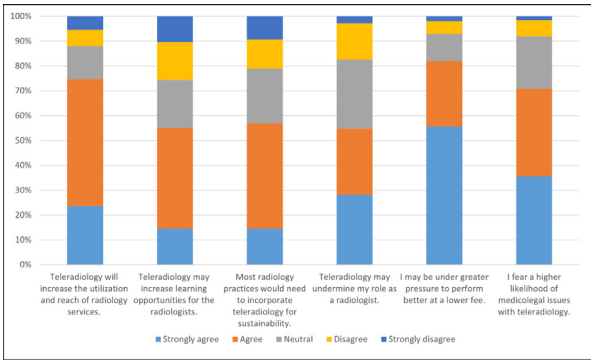

Fig. 5: The opinions regarding the perception of teleradiology in the radiology profession. The total responses across all respondents for each question and level of agreement are provided. (multiple responses question)

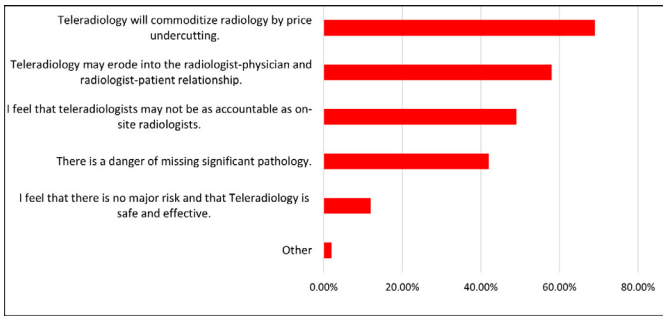

Fig. 6: Opinions of respondents about the risks of using teleradiology (multiple responses question)

teleradiology (n=219/309, 71%) and that it may undermine their role as a radiologists (n=169/309, 55%).

The Risks of using Teleradiology

The risks of using teleradiology perceived by the radiologists are that it would commoditize radiology by price undercutting (n=214/309, 69%), disrupt the radiologist-physician and radiologist-patient relationship (n=181/309, 58%) and not being as accountable as on-site radiologists (n=151/309, 49%). Forty-two percent (n=130/309) of participants believed that there is a danger of missing significant pathology while utilizing teleradiology (Fig. 6). However, twelve percent (n=37/309) of participating radiologists felt that there is no major risk and that teleradiology is safe and effective.

Teleradiology is an Asset for the Stakeholders

70% (n=217/309) of participants voted that teleradiology can be an asset or a liability, depending on the circumstances. However, a significant number of participants (n=192/309, 62%) considered teleradiology an asset for the stakeholders, including the radiologist, referring physician and the patient (Table 4). Others (n=17/309, 5%) believed that teleradiology is an asset for the hospital owners.

Opinion on Teleradiology (Open question)

In a free text question, the participants were asked to give their opinion or comment on teleradiology. A total of 68 comments were obtained. Out of these, 29 were positive comments in favor of teleradiology, stating that it is essential to address the radiologist shortage for better workflows and supplements the income of the radiologists. However, an equal number of the participants (28) also revealed their concerns, focussing on lower remuneration paid to the teleradiologists, lack of proper history/clinical details of the patients, insufficient quality assurance, and reduced radiologist-referring physician /patient interaction. However, some participants revealed their willingness to adopt teleradiology if paid well. Others commented that standardization of reporting charges should be done. Some of the comments by the participants are given in Table 5.

Table 4: Do you think that teleradiology is an asset for the stakeholders? (multi responses question)

Teleradiology is an asset for the radiologist.	66/309	21%
Teleradiology is an asset for the referring physician.	70/309	23%
Teleradiology is in the patients benefit.	56/309	18%
Teleradiology can be an asset or a liability depending on the circumstances.	217/309	**70**%
Other(free text responses)	17/309	5%

DISCUSSION

Teleradiology is integral to any successful radiology practice due to many intrinsic advantages that cannot be ignored, as our survey corroborates. However, at the same time there is a level of concern regarding how teleradiology is used currently or might be used in the future. The number of surveys to discern the status of the teleradiology practice in different countries, is unexpectedly small (1, 22, 23). Based on these survey responses, teleradiology is practiced by radiologists in different practice settings, career stages, and subspecialties and is used for interpreting a wide spectrum of imaging modalities.

Demographics and teleradiology practice set-up

Teleradiology groups can source radiologist hours from both full-time and part-time radiologists, regardless of their geographical location or primary affiliations, enabling them to offer scalable radiology services (2). The survey results revealed that the site of the main professional activities of the respondents are: diagnostic center (single center or multicentre practice), followed by academic and research private or government hospitals, and non-academic private or government hospitals. There were 31/309 respondents who were exclusively teleradiologists. About one-third of the respondents work in a small group of 2 to 5 radiologists, while others practice in larger groups of 5 to 10 radiologists (17%), 10 to 20 radiologists (7%) or greater than 20 (14%). The respondents in a European survey were also from a heterogeneous practice distribution, with the majority working at public or private hospitals (55 %), university hospitals (36%), or private practice or private medical centers (24%) (1). Similar to our survey, slightly less than half of the participants work in a small group of 2–10 (41%); others in larger groups between 10 and 20 (22%) or over 20 (30%) (1), highlighting an important role of teleradiology in augmenting staffing of smaller practices.

Table 5: Opinions on teleradiology (open question)

S. No.	*Positive comment*
1	The continued growth of teleradiology is essential to address the radiologist shortage in our country
2	Teleradiology should be legalized in India and given proper framework, and optimal reimbursement ensured
3	Best tool to address shortage of radiologists
	Negative comments
1.	Strongly against teleradiology for providing cheap reporting charges
2.	Teleradiology decreasing the job offers of a radiologist
3.	Significant amount of history is not provided in teleradiology. Lack of communication with the referring physician. And pay incentive per case is too low in India.

Teleradiology utilization

The surveyed radiology professionals are generally positive and encouraging of the use of teleradiology. Our survey results indicate that teleradiology plays a pivotal role in modern radiology practice and is currently being used in diverse practice settings and regions in India. Teleradiology is not trivial in its contribution to the field as highlighted by the approximate number of cases per month reported via teleradiology, wherein 45 % of participant radiologists reported 100-500 studies per month (5-20 cases /day) using teleradiology and 14% participants reported more than 1000 per month (>40 cases/ day) in our survey.

In the current era of radiologist shortages, teleradiology practice is now pivotal to ensure that radiologists provide service access to a larger community rather than a single center (24). Based on the survey responses, the use of teleradiology is prevalent among radiologists in different practice settings. In our study, a large majority of the participating radiologists (74%) affirmed that they are utilizing teleradiology either at home (54%) or within a hospital or imaging center to connect to another center (30%), or everywhere using a mobile device/ laptop (23%). Similarly, in another survey conducted to provide a snapshot of various teleradiology practices in Turkey, 51% of the respondents stated that they reported images at home for multiple centers, while others performed teleradiology on-site for a single center (17%), on-site for multiple centers (14%), or at home for a single center (18%) (23).

In our survey, the participating radiologists voted for routine case reporting (57%) and night-time readings (including emergency call reporting) (57 %) as the most prominent use of teleradiology. Similarly, a Swiss teleradiology survey organized in 2004 reported emergency service as the most prominent intent for the use of teleradiology, followed by image distribution and expert consultation (25). However, in a European survey organized in 2012, aimed to evaluate the current opinion and future vision about teleradiology, the European radiologists rated the distribution of images within the same institution for efficient workload sharing as the most frequently used form of teleradiology (71 %) followed by night-time and weekend readings from home (44%) (1).

Technology utilization

A robust infrastructure and provision of technologies are crucial for the successful execution of teleradiology services. Digital Imaging and Communications in Medicine (DICOM) compatible Picture Archiving and Communication System (PACS) and Radiology Information System (RIS) are vital to managing image archives, record-keeping and billing (26). In our study, a majority of participating radiologists (70%) confirmed using the PACS/RIS system in their institute or hospital to store radiological images. For image analysis, a significant number of the respondents have a dedicated teleradiology workflow, while others prefer to use freeware such as Osirix or dial-in to hospital PACS.

In general, several methods are used by radiologists for preparing reports such as direct dictation to a secretary, handwritten on paper for subsequent typing, and dictation on a tape handset with subsequent transcription. But these methods are time and labor intensive and expensive (27). Voice-to-text software permits accurate and fast report generation in real-time, thereby increasing radiologist productivity (24). In our survey, the most preferred reporting methods were radiologists typing their own reports using shortcuts, followed by voice recognition or dictating to a transcriptionist. A small percentage preferred handwritten report.This is a positive trend in line with the advancements and cost of speech recognition software.

Attitudes and perceptions of teleradiology services

To meet the additional demand for imaging in case of trauma and emergency settings, along with understaffing challenges, teleradiology appears as an obvious solution supplementing, supporting,

and filling in the gaps of the on-site radiology workforce (28). Additional comments were obtained in our study regarding the advantages, risks, and perceptions of teleradiology services. The benefits of teleradiology were evident to most survey participants, with the majority identifying its primary advantage as being a technology that shortens the wait hours and turn-around-time for reports (74%), reduces the cost of reporting (66%) and efficiently distributes the workload (56%). Additionally, the ability to improve work-life balance (50%),

greater availability of radiologists for referring physicians (50%), improved overall service (49%), and decrease in radiologist attrition rate (47%), were also appreciated. A similar response was received in a US teleradiology survey where participants agreed that teleradiology helps provide after-hours coverage, reduces turnaround time for final interpretations, provides multispecialty coverage, helps provide coverage when understaffed and reduces turnaround times for preliminary interpretation (22). A European survey reported the possibility for collaboration as the most valuable advantage (74 %), followed by the ability to efficiently distribute the workload (70 %).

Our survey captured some fears and risks of certain business practices in teleradiology, 82% of participants expressed concern that teleradiology will commoditize radiology by price undercutting. Similar concern was also clearly expressed in a survey conducted in Italy, where researchers believed that while economics is a prominent driver for the radiologists to seek or perform teleradiology, low pricing may result in poor reporting quality and dissatisfaction with teleradiology (29). It is also feared that such teleradiology practices will reduce radiology to a tradable "commodity" (1, 30).

The open questions"offered t"e participants an opportunity to express their opinions regarding the current and future role of teleradiology. The supporting text opined that teleradiology has become a necessary part of conventional radiology practice and is necessary for better workflows especially for the remote and radiologist-understaffed areas. However, the survey highlighted the lower remuneration to the teleradiologists as a major concern with cascading adverse effects on the quality of reporting as well as teleradiology as a business. These would need to be addressed with a formulation of national guidelines and stronger support from within the radiologist community to ensure a fair and healthy integration of teleradiology with conventional practice. The survey results affirmed the fact that the radiologists in India are against the commoditization of teleradiology practice but not really to the practice of teleradiology itself.

There exist several limitations to this study. First, the response rate was low at approximately 3%. Since this was a voluntary nationwide electronic survey, radiologists find it challenging to devote time for such activities. Moreover, the data reflect the respondents' perspectives and opinions on the current state of teleradiology practice; there is a lack of objective data detailing the advantages and disadvantages of teleradiology (25, 29). The survey did not distinguish in the free text option between the technology, clinical and commercial aspects of teleradiology, and therefore there is a potential bias towards negative responses from those who feel the commercial aspects of teleradiology threaten their current status quo.

The future directions for teleradiology in the rural healthcare sector in India and its impact

This survey highlights increasing adoption and optimism among Indian radiologists toward teleradiology as a key enabler of equitable healthcare delivery. Further, the advancement in deep learning curated imaging, 5G connectivity, and cloud-based platforms, leveraging portable imaging devices and mobile diagnostic units would ensure quicker and more accurate radiology services, even in the remote and most underserved areas (13, 16, 17, 31, 32). Integration with government initiatives such as Ayushman Bharat and public-private partnerships will help reduce costs and ensure scalability, making teleradiology more sustainable. Furthermore, training programs for healthcare workers in rural areas (which can be delivered online) will empower them to operate imaging systems and manage tele-consultations, augmenting service proficiently. Teleradiology will bring transformation by reducing the delays in diagnosing critical conditions, boosting early detection of diseases, and lowering mortality rates and healthcare costs (26, 33). Adoption of teleradiology in India will bridge the gap between healthcare in rural and urban areas by making radiological opinion accessible and affordable, and leading to a more inclusive healthcare ecosystem (34).

CONCLUSION

This survey provides insights on the current trends in teleradiology utilization patterns in India, demographics of the practice types, perceptions and attitudes of the Indian radiologist community regarding the potential advantages and risks of teleradiology as a client or provider. The majority (75%) of participants agreed that teleradiology would increase the utilization and reach of radiology services, lower the cost of reporting (66%), and would become essential for sustainability (57%).

Teleradiology is viewed as an asset for key stakeholders, i.e., the radiologist, the referring physician and the patients. Major concerns regarding lower remuneration for the teleradiologist and lower cost of reporting need to be addressed for seamless integration and healthy and fair business. Stringent quality assurance practices within teleradiology would also be key to allaying any fears in the community. We believe that the results of this survey would be useful for individual radiologists, radiology practices, hospitals and hospital administration as well as the national health initiatives of the government to provide the necessary infrastructure and environment to implement teleradiology and reap its benefits to enhance and standardize the current state of radiological services.

TAKE HOME POINTS

- The survey about teleradiology utilization patterns, perceptions and attitudes of Indian radiologists reveals an overall positive perception within the Indian radiologist community. The radiologists opine that teleradiology increases the utilization, reach, and sustainability of radiology services, reduces turnaround time, reduces cost, improves workload distribution, improves work-life balance, improves radiology support for referring physicians and improves overall service.
- The major concern pertains to the commoditization of radiology by price-undercutting, for which healthy and

fair business practices would need to be implemented collectively by the radiologist community. Concerns pertaining to quality issues of teleradiology should be addressed by following stringent quality assurance processes within teleradiology services.

- Teleradiology appears to have a significant impact on nationwide radiology practices. Adequate support by the hospital administration and health initiatives of the government would be essential to its success.

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