ORIGINAL RESEARCH

Navigating Challenges in Teleradiology Implementation: A Case Study from Saudi Arabia's Healthcare System

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Background and Aims: Teleradiology is the practice of interpreting medical images acquired in an off-site location. Teleradiology has been utilized widely around the world to address the needs for subspecialty coverage, workload balancing, and as a solution for understaffing. This study aims to assess the perceptions of teleradiology among radiologists in Saudi Arabia, investigate any challenges they might face, and explore strategies that would help mitigate those challenges.

Methods: A cross-sectional study using a self-administered electronic questionnaire was conducted to collect responses from radiologists practicing or having practiced teleradiology in Saudi Arabia. The questionnaire was conducted from January to June 2023, and 105 responses were included in the analysis. The responses were analyzed using chi-squared testing to investigate factors affecting the radiologists' perceptions.

Results: The most common challenges for teleradiology were access to patients' health records, access to prior imaging exams, and concerns about image quality assurance. Around 74% of participants perceived teleradiology to be beneficial for geographic, after-hour, and subspecialties coverage. Teleradiology was also perceived to help reduce the turn-around time of radiology interpretations. Better communication with referring physicians and technologists was seen as a way to help improve teleradiology services.

Conclusion: The findings suggest that the perception of teleradiology's challenges and benefits may not be influenced by experience, workplace, or subspecialty. Emphasis should be placed on the importance of quality assurance of images acquired remotely. Addressing the concerns and challenges related to access to patients' health records is also crucial to ensuring the successful implementation of teleradiology in the country.

Keywords: teleradiology, radiology, diagnostic imaging, image interpretation, Saudi healthcare

Introduction

Teleradiology, a subtype of telemedicine, is the practice of interpreting diagnostic images acquired at a location different from where the interpreting radiologist is located.[1] Teleradiology involves the transmission of diagnostic images between different locations via telecommunication systems.[2] It has become an indispensable part of radiology practices. The widespread adoption of Picture Archiving and Communication Systems (PACS) and digital systems by radiology departments and the increasing availability of high bandwidths that allow high-speed data transmission made the development of a teleradiology service model possible.[1]

Teleradiology was first introduced in the mid-90s in the United States, and since then, its use has increased.[1] During its growth, teleradiology encountered a diverse range of perspectives within the radiology community.[3] A major concern

among radiologists was that it would replace conventional and local radiology practices.[4] Others expressed concerns about the quality of the service.[3] Nonetheless, teleradiology has become a reality and will continue to spread.

Teleradiology offers the benefit of giving hospitals in rural areas that are lacking in some sub-specialties access to radiology interpretation services.[3] In addition, teleradiology can be used for a second opinion in critical cases and after-hour on-calls.[5] It has also been found helpful in balancing workload.[6]

Teleradiologists, being in a non-conventional radiology department setting, face many challenges during the service they provide. Potential challenges include accessing patient medical records and previous radiological examinations, contacting referring physicians, and quality control.[4] A study conducted in the United States found that the most common challenges noted by teleradiologists were access to electronic medical records, quality assurance, and technologist proximity.[7] Another study in Italy found that many radiologists had concerns about insufficient communication with the referring clinician.[8]

Radiology in Saudi Arabia has been experiencing significant growth, with advancements in technology and an increase in the volume of services provided. It is reported that around 12 million radiology procedures have been performed during 2021.[9]

In an effort to improve the efficiency and quality of diagnostic imaging services as well as reduce the time required to obtain the service, the Saudi Ministry of Health (MOH) introduced the Public-Private Partnership (PPP) project, as a part of the Health Sector Transformation to achieve Vision 2023, the kingdom's national transformation program. This is the first partnership project of its kind between the public and private sectors in which radiology departments in selected public network hospitals would be privatized. The PPP project will incorporate teleradiology services between the network hospitals.[10–12]

In addition to the PPP, MOH established Seha, the first virtual hospital of its kind in the country in which many telehealth services are provided, including teleradiology. The Seha virtual hospital has been offering teleradiology services through the national teleradiology platform since 2020 which is expected to expand and include all teleradiology providers nationwide.[13] Additionally, the private sector has been actively involved in teleradiology, with several teleradiology private providers operating in the country. The MOH is the entity responsible for licensing and overseeing these private teleradiology providers.[9]

Despite its growing practice around the world, teleradiology is considered relatively new to the Saudi Market and is expected to develop in the coming years.[11,14] In light of all these rapid developments in the field of teleradiology in Saudi Arabia, it is incumbent to explore the teleradiologists' perceptions of the field. A study conducted in Saudi Arabia by Al-Dahery et al found that many radiologists believed that teleradiology was a useful tool for image interpretation, especially during the COVID-19 pandemic, which could enable decreasing the risk of infection and helping distribute the workload.[15] A deeper understanding is needed to explore any challenges associated with teleradiology practice and develop strategies to overcome them.

This study aims to explore the perceptions of teleradiologists regarding the benefits of teleradiology and investigate any challenges they might face while providing the service. It also tries to suggest possible solutions to mitigate any challenges and explore strategies that might help to improve teleradiology practice. In doing so, this paper is trying to shed light on the current status of teleradiology in the country.

Materials and Methods
Study Design and Setting

This cross-sectional study used a previously published and validated questionnaire to collect responses from participants.[7] Ethical approval from the researcher's institution's institutional review board (IRB) was obtained to conduct this study (project number E-23-7599, King Saud University). The survey was conducted in the period from February to June 2023. Radiologists practicing or have practiced teleradiology in Saudi Arabia during the past ten years were invited to participate. The electronic version of the questionnaire designed in Microsoft Forms was distributed to teleradiologists in hospitals by the research team members. In addition, the questionnaire was disseminated through emails and social media outlets to the Radiological Society of Saudi Arabia (RSSA) members.

Participants and Sample Size

According to the recent MOH statistical yearbook, there are 3218 radiology clinicians (resident, registrar, and consultant) in different healthcare sectors (Ministry of Health (MOH), governmental non-MOH sector, and private sector) in Saudi Arabia.[9] Of those clinicians, 783 are radiology consultants licensed to practice radiology. It is unknown how many of them are involved in any form of teleradiology. The study applied non-probability convenience and snowball sampling in which 148 participants responded to the survey which is an acceptable sample size for the purpose of this study. However, only radiology consultants who have participated or are practicing teleradiology in Saudi Arabia were included in the analysis.

Study Tool

A self-administered electronic questionnaire was utilized in this study. The aims were introduced at the beginning of the questionnaire, and a consent form was provided for each participant to sign. No identifying information about the participants was collected.

The questionnaire comprised two sections and had a total of 12 closed-ended questions. The first section was concerned with collecting data on the nature of the provided teleradiology service, the radiologist's subspecialty, coverage hours, the radiologist's work setting, and years of experience. The second section investigated three domains regarding participants' perceptions of teleradiology practice. The first domain addressed the concerns and challenges that teleradiologists may encounter while performing teleradiology. The participants were asked to respond to statements on a Likert scale about potential challenges and rate each statement from 1 to 5 according to how challenging they found each one (1: not challenging at all; 5: extremely challenging). The second domain investigated some attributes and strategies that could improve teleradiology services in the country. The participants had to rate statements on a Likert scale from 1 to 5 depending on how useful they thought it would be improving teleradiology services (1: not useful at all; 5: very useful). The third domain investigated the potential benefits of adopting teleradiology in healthcare. Participants were asked to rate each statement on a 5-point Likert scale (1: strongly agree; 5: strongly disagree). Table 1 summarizes the domains and variables addressed in the questionnaire.

Table 1 Domains and Items Addressed in the Questionnaire

Domain	Variables
Perceived challenges to teleradiologists	Communication with the technologist
	Communication with the referring physician
	Communication with other radiologists
	Access to prior exams
	Access to Electronic Health Record (EHR) system
	Credentialing
	Reimbursement
	Quality assurance
	Privacy or security
	Central PACS integration
Improving teleradiology services	Licensing and credentialing
	Teleradiology regulations across the country
	Technical standards
	Ease and rapid Communication with the referring physician
	Ease and rapid Communication with the technologist
Potential benefits of teleradiology	Geographic coverage
	After-hour coverage
	Multi-specialty coverage
	Turn-around time
	Coverage when understaffed

Statistical Analysis

Descriptive and inferential statistical analyses were conducted using IBM SPSS Statistics for Windows, version 26 (IBM Corp., Armonk, N.Y., USA). Chi-squared tests were performed to compare different groups of participants (work setting, years of experience, subspecialty) according to their responses to each questionnaire item. The P values of the statistical test were reported; the significance threshold was set at 0.05.

Results

A total of 148 participants responded to the survey, of whom 43 were excluded because they never practiced teleradiology. Only radiology consultants who have participated or are currently practicing teleradiology in Saudi Arabia were included in the analysis (105 responses were included; 67 are currently practicing; 38 have practiced in the past).

Figure 1 shows a description of our participants' experience, in terms of the number of years passed after finishing residency (Figure 1a), workplace (Figure 1b), and radiology subspeciality (Figure 1c). Most of the participants have
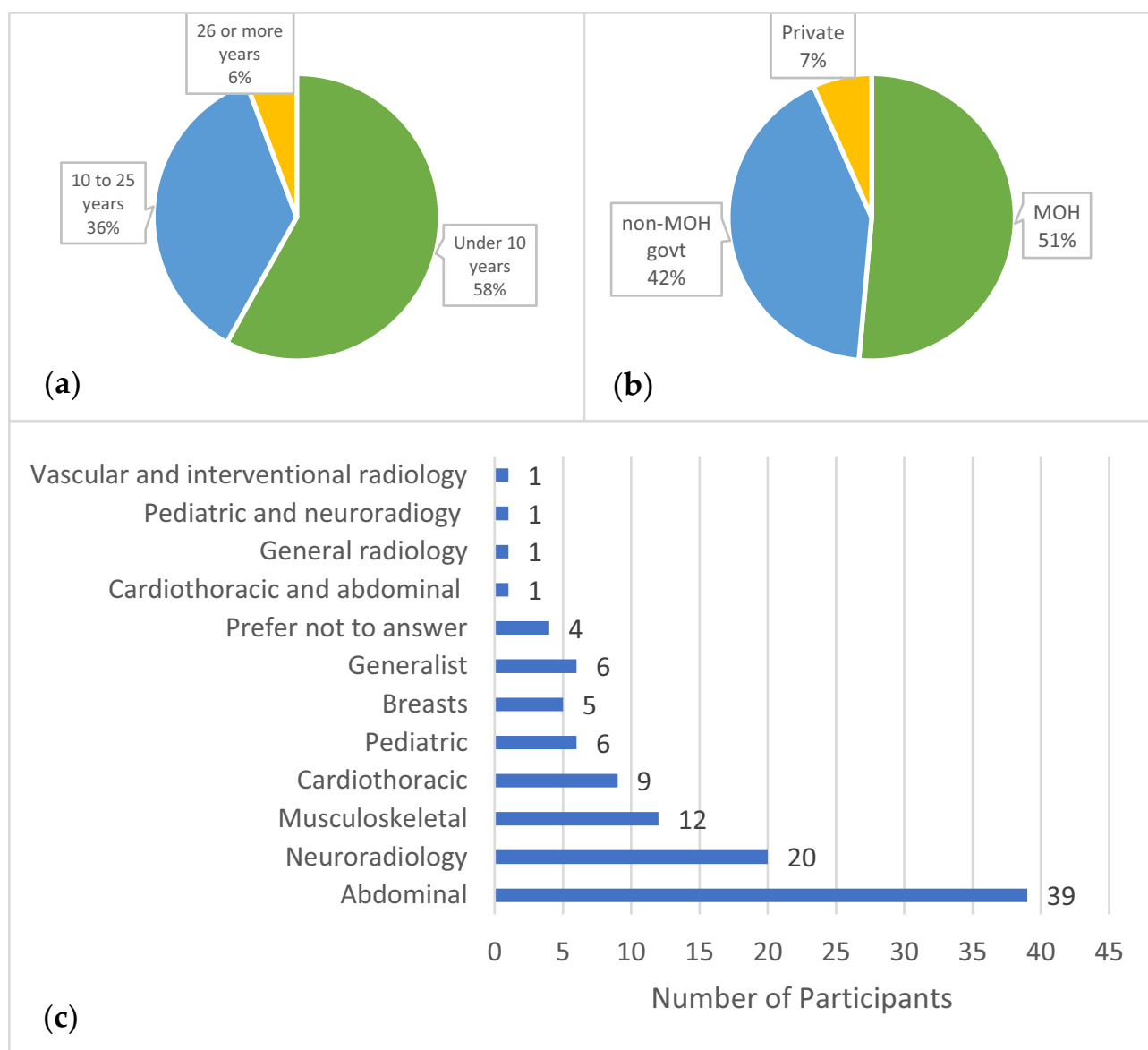

Figure 1 Description of study participants. (**a**) Distribution of participants according to years after finishing residency. (**b**) Distribution of participants according to the workplace. (**c**) Subspecialties of the participants.
Abbreviations: MOH, Ministry of Health; non-MOH govt, governmental institutions which are not part of MOH; Private, private hospitals.

finished their residency within ten years (58%). The work setting was categorized into Ministry of Health (MOH), non-MOH governmental, and private centers. Around half of our sample were employees of the Ministry of Health (MOH). The non-MOH governmental hospitals include university, military, and national guard hospitals. Regarding participants' subspecialties, abdominal and neuroimaging, were two of the most common among the participants (37% and 19%, respectively).

Half of the participants who are currently practicing teleradiology, as shown in Figure 2a, estimated that teleradiology cases constitute only 10% or less of the annual number of radiology cases seen by them. MRI and CT modalities were the most interpreted images by the participants. About 82% and 74% of the participants indicated that they interpreted MRI and CT images, respectively, while only 4% of the participants indicated that they interpreted Mammography and PET images (Figure 2b). Figure 2c shows a description of the nature of the teleradiology activity in which the participants were involved, which can be categorized into two categories: internal and external. As indicated in Figure 2c, about 84% of the participants were involved in external teleradiology services. On the other hand, about 38% of the participants indicated that they perform teleradiology internally for their employers. Most of the participants indicated that they perform teleradiology readings on weekdays, with 50% of them providing the service during regular business hours and 70% doing so during the evenings (Figure 2d).

The percentage of participants who indicated that a given characteristic was somewhat challenging or extremely challenging is shown in Table 2. The average percentage of participants who agreed on the characteristics in Table 2 to be challenging to teleradiology practice is 38% (±17%). A common area of concern among the participants was accessing patients' records in the electronic health record (EHR) system where 69% of the participants indicated that accessing patients' records was a challenge. Similarly, access to prior imaging exams when interpreting an image from a remote location is indicated as challenging by 60% of participants. Quality assurance of images acquired remotely was also a concern to 52% of the participants. On the other hand, privacy and security of medical data were not a concern to 78% of the participants.

There is no indication that years of experience influence whether the characteristics in Table 2 were perceived as challenging (see Appendix Table A.1). However, workplace affects whether lack of proximity to referring physicians (p=0.045<0.05) and to other radiologists (p=0.021<0.05) were perceived as challenging by the participants.

Most participants (74%±4) indicated that applying the strategies listed in Table 3 could be useful and would lead to the improvement of teleradiology practice in the country. There is no indication that experience would affect whether the participant perceives a particular strategy as useful or not (see Appendix Table A.2). Similarly, there is no influence of the workplace on how teleradiologists view a strategy as useful, with the exception of the attributes of ease of communication with referring physicians (p=0.032<0.05) and ease of communication with technologists (p=0.00<0.05).

The potential benefits of teleradiology as perceived by the participants are shown in Table 4. Most participants (71%±7) agreed that teleradiology was beneficial and helpful to their practice in the different aspects stated in Table 4. There is no evidence, however, that years of experience affect the perceived benefits of teleradiology by the participants (see Appendix Table A.3). Similarly, there is no indication that the workplace affects whether the items in Table 4 are perceived as an advantage of teleradiology. Nonetheless, the perceived benefit of providing coverage when understaffed is influenced by the workplace (p=0.006<0.05).

Discussion

Although teleradiology is relatively new to the Saudi healthcare framework, it has received attention from public and private healthcare providers in recent years. This paper provides a deeper look into the nature of challenges that teleradiologists face while providing the service, which has not been explored in-depth on a national level. The study also examines radiologists' opinions on possible strategies that may help mitigate those challenges. Also, the benefits of teleradiology as perceived by teleradiologists were explored.

Since abdominal imaging and neuroimaging are two of the most rapidly growing sub-specializations in radiology (Rosenkrantz et al, 2020), these subspecialties were the most common among our participants (abdominal imaging represented 37% and neuroimaging 19%).
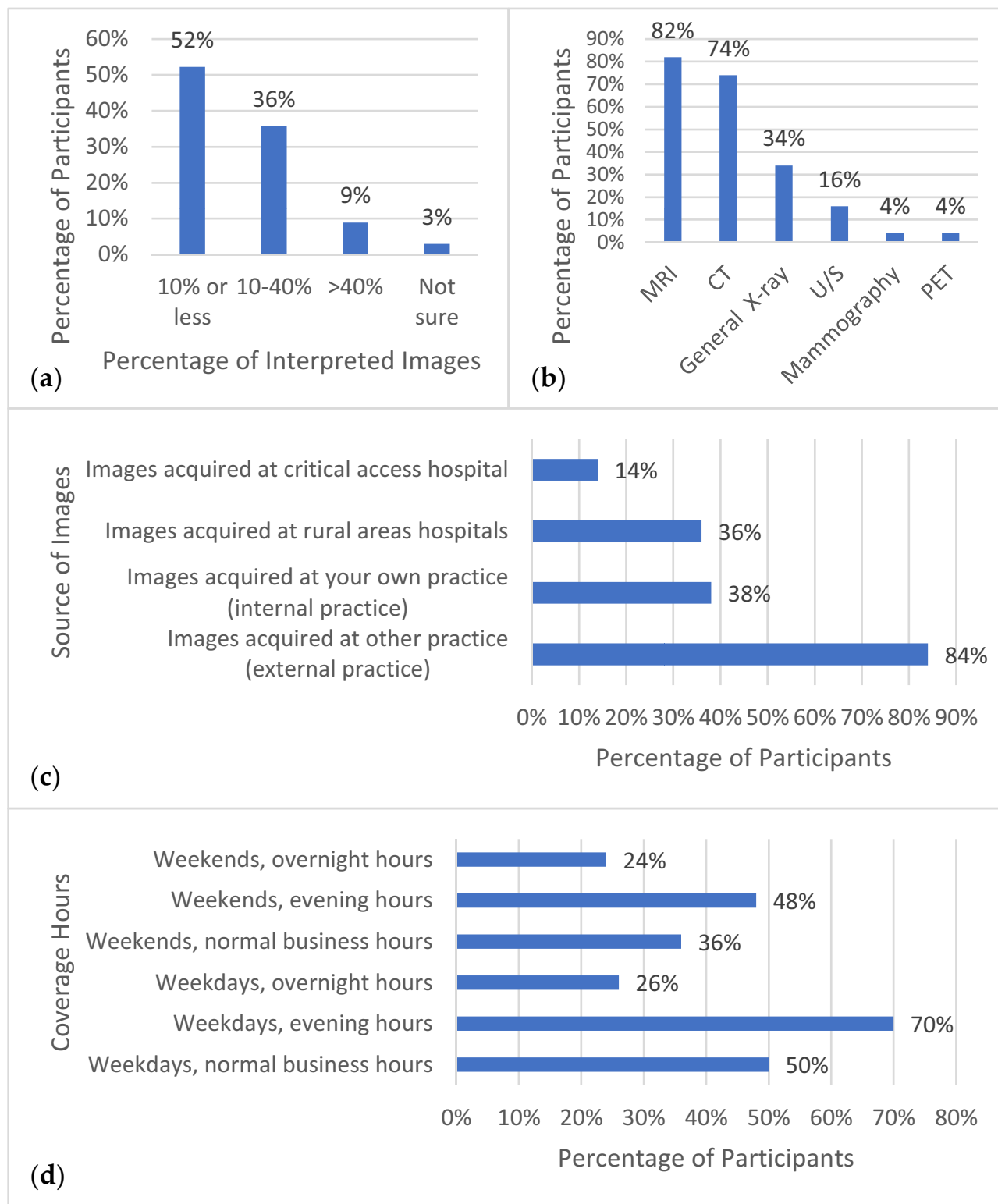
Figure 2 Description of provided teleradiology services. (**a**) Percentage of teleradiology images interpreted by the participants out of their annual interpretation volume. (**b**) Types of teleradiology images interpreted by the participants. (**c**) Source of teleradiology images interpreted by the participants. (**d**) Coverage hours for teleradiology services by the participants.
Abbreviations: MRI, Magnetic Resonance Imaging; CT, Computed Tomography; U/S: Ultrasonography; PET, Position Emission Imaging.

Table 2 Percentage of Participants Who Indicated a Given Characteristic as Somewhat Challenging or Extremely Challenging

Challenge	Percentage of Participants
Lack of proximity to the technologist	35%
Lack of proximity to the referring physician	38%
Lack of proximity to other radiologists	21%
Accessing prior imaging exams	60%
Accessing the patient's record in the Electronic Health Record (EHR)	69%
Achieving credentialing for interpreting off-site exams	25%
Receiving reimbursement for interpreting off-site exams	28%
Performing quality assurance of off-site exams	52%
Maintaining privacy and security of off-site exams	22%
Integrating the off-site exams into a practice's central PACS	30%

Table 3 Percentage of Participants Who Indicated a Given Strategy Somewhat Useful or Extremely Useful

Strategy	Percentage of Participants
Standardization of licensing and credentialing	72%
Standardization of regulations across states	80%
Technical interpretation standards	68%
Ease of communication with referring physicians	72%
Ease of communication with technologists	76%
Rapid communication with referring physicians	74%
Rapid communication with technologists	76%

Table 4 Percentage of Participants Who Indicated Agree or Strongly Agree to the Stated Potential Benefits of Teleradiology

Statement	Percentage of Participants
Reading off-site exams helps my practice provide geographic coverage	79%
Reading off-site exams helps my practice provide after- hours coverage	70%
Reading off-site exams helps my practice provide multi-specialty coverage	70%
Reading off-site exams helps my practice reduce turn-around times for preliminary interpretations	62%
Reading off-site exams helps my practice reduce turn-around times for final interpretations	67%
Reading off-site exams helps my practice provide appropriate coverage when understaffed	78%

Half of the participants responded that the teleradiology interpretations they perform account for less than 10% of their annual image interpretation volume. This suggests that while teleradiology is being adopted in both the public and private sectors, it still represents a small proportion of the overall radiology practice. In contrast, in the United States, the majority of teleradiologist interpretations account for more than 50% of each teleradiologist's annual image interpretation volume.[7]

According to our participants, MRI and CT were leading the number of requested teleradiology interpretations. This can be attributed to the fact that hospitals and some rural areas lack specialized radiologists for MRI and CT, which are

complex modalities requiring specialist interpretations. In addition, both modalities are known to be the most critical investigations in the area of neurosurgery, necessitating a specialist's precise interpretation.[16]

The nature of the teleradiology service provided by the participants can be divided into two categories: internal and external. The former refers to when the teleradiologist interprets images that are produced in other branches or campuses of the teleradiologist's employer's institution, while the latter refers to when the teleradiologist interprets images that were produced outside their employer's institution. About 84% of the participants were involved in external teleradiology services. On the other hand, about 38% of the participants indicated that they performed teleradiology internally for their employers. This suggests that some healthcare institutions adopt insourcing of radiology to distribute workload and cover any staff shortage between different branches. The insourcing of radiology has been found to provide value to better radiology services.[17,18]

Access to patient history is essential for accurate diagnosis, as a limit to access to patient history might lead to diagnostic errors.[19,20] Expectedly, the most reported challenge by the participants was accessing patients' records which was indicated by 69%. This agrees with the findings of Rosenkrantz et al in which 75% of their sample deemed accessing patients' records as challenging.[7] Similarly, it was found in other studies that access to patients' health records was a challenge.[4,8] In addition, insufficient integration of clinical history was revealed as a common disadvantage of teleradiology.[21]

Other key challenges indicated by our sample were access to prior images and the quality assurance of images acquired remotely. These challenges have been reported in other studies as well.[3,7,8] Access to prior images is critical as it increases the accuracy of the diagnosis and helps in comparative analysis.[22]

Because the Saudi Commission for Health Sciences (SCHS) is the centralized licensing body for medical professionals in the nation, participants did not express any concerns about credentialing. A radiologist would be qualified to practice teleradiology if he holds a SCHS license. In contrast to the United States, radiologists who interpret images from other states must hold licenses from both the state in which the image is produced and the state in which it is interpreted under the American College of Radiology (ACR) requirements.[23]

According to the participants, reimbursement for provided teleradiology services posed minimal concerns. Only 28% of the participants found it challenging to obtain reimbursement. This level of satisfaction may indicate that teleradiology practice is likely to succeed and continue to attract highly experienced radiologists. However, more research could be done to explore the satisfaction of the compensation model in the country.

In our study, most of the proposed strategies to improve the field of teleradiology were perceived to be useful by the majority of our participants. This disagrees with the findings of Rosenkrantz (2019) as most of the strategies were deemed not useful by the majority of their participants.[7]

Around 71% of participants had a favorable view regarding the benefits of teleradiology. The participants perceived teleradiology to have several benefits, including expanding coverage to include different geographical locations, after-hours coverage, and subspecialties. In addition, teleradiology was perceived to help reduce turnaround times and provide coverage when understaffed. These benefits have also been demonstrated in numerous studies.[6,7,21] In addition, teleradiology has been regarded as beneficial during the COVID-19 pandemic by radiologists in Saudi Arabia. Al-Dahery et al found that most of their participants had a positive view of teleradiology in reducing infection risk during the pandemic.[15]

Overall, the findings of this study suggest that teleradiology has the potential to significantly improve the quality and accessibility of healthcare in Saudi Arabia. However, some challenges must be addressed to fully realize the benefits of teleradiology. The findings of this study have several implications for the practice. First, it is essential to address the challenges identified by the participants, such as accessing patients' records and prior imaging exams and ensuring the quality of images acquired remotely. This can be done by developing and implementing policies and procedures that specifically address these challenges. Second, it is vital to promote the benefits of teleradiology to both healthcare providers and patients. Third, the attributes identified by the participants as being necessary for improving teleradiology services should be incorporated into the design and implementation of teleradiology programs. This includes ensuring that teleradiology systems are integrated with the EHR system and that there are mechanisms in place to facilitate communication between teleradiologists, referring physicians, and technologists.

Given the current status of teleradiology in the country, it is advised to issue guidelines to monitor teleradiology services to ensure the production of high-quality diagnostic interpretation of medical images. It is important to emphasize that the purpose of the teleradiology model is to improve the quality of the service.

As for the limitations of this study, the study tool could not determine the total number of teleradiology providers for which the sample size could not be accurately calculated. Future studies with larger sample sizes may be able to better represent teleradiology providers. In addition, whether the COVID-19 pandemic accelerated the adoption of teleradiology by the public and private sectors as a means to combat the pandemic was not explored in this study. Also, future studies should investigate the impact of incorporating artificial intelligence into teleradiology practice, which understandably could alter the landscape of teleradiology practice. Further studies should also examine the impact of incorporating artificial intelligence into teleradiology, which could change the current teleradiology landscape in the country.

Conclusion

This study provided insights into teleradiology's current state and prospects in Saudi Arabia. It explored the perceptions of teleradiologists regarding their practice. The results of this study may indicate the feasibility of integrating teleradiology into the routine work of radiologists. As the demand for teleradiology is expected to increase in the future, quality assurance of images becomes essential. Future research should evaluate the effectiveness of strategies to address the challenges identified in this study, as well as the impact of teleradiology on patient outcomes and the potential economic value of adopting teleradiology in the healthcare system.

Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board of King Saud University (E-23-7599; date of approval 14 Feb 2023) and Ministry of Health (23-8 M; date of approval 10 Jan 2023)

Data Sharing Statement

The data supporting this study's findings are available upon request from the corresponding author.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare no conflicts of interest.

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