Teleradiology in India during the COVID-19 pandemic: Merits, pitfalls and a future perspective

Sudhan Rackimuthu[1], Mohammad Mehedi Hasan[2*], Ishita Ray[3], Abdul Moiz Sahito[4], Pranshu Chawla[5], Diya Ghosh[6]

1. Father Muller Medical College, Mangalore, Karnataka, India.
2. Department of Biochemistry and Molecular Biology, Faculty of Life Science, Mawlana Bhashani Science and Technology University, Tangail, Bangladesh.
3. Mahatma Gandhi Memorial Medical College, Indore, India.
4. Dow University of Health Sciences, Karachi, Pakistan.
5. Narayan Medical College and Hospital, Bihar, India.
6. Department of Biotechnology, Heritage Institute of Technology, Kolkata, India.

*Correspondence: Mohammad Mehedi Hasan, Department of Biochemistry and Molecular Biology, Faculty of Life Science, Mawlana Bhashani Science and Technology University, Tangail, 1902, Bangladesh.

Email: mehedi.bmb.mbstu@gmail.com

ORCID: 0000-0002-3871-889X

Telephone: +8801983027853

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1. Teleradiology in the context of developing countries such as India is an extremely promising and tactful modality in offering invaluable medical support to those in need especially amidst the challenges posed by the COVID-19 pandemic.

2. With the advent of new technological breakthroughs and continuous progress in the fields computer science and electronic engineering such as Artificial intelligence (AI) as well as cloud computing the future of teleradiology seems promising.

3. Pitfalls of teleradiology and telemedicine at large must be acknowledged, and steps must continue to be taken by relevant stakeholders to bolster and support its growth.

Reflexivity Statement: The authors include two females and four males and span multiple levels of seniority. While four of the authors specialize in public health and health policy in India, the other two are scientists with expertise in radiology. All six authors have extensive experience conducting global health research.

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Abstract

The field of teleradiology has been of interest for almost 55 years and its potential prospects for health care have been constantly assessed and investigated. In view of the global preventive measures, such as social distancing and hand hygiene, the ongoing COVID-19 pandemic has further accentuated the necessity of telemedicine and teleradiology. In a country as densely populated as India wherein radiologists are often fragmented, teleradiology can prove to be a lifesaving technology and aid dampen the repercussions stemming from the highly skewed doctor to patient ratio. Although innovative, the effective adoption of teleradiology faces several obstacles in India such as inadequate technological infrastructure, a lack of knowledge among most medical practitioners, urban-rural disparities, and a lack of financing. Similar challenges continue to also be faced by several other developing countries across the globe. This article therefore aims to elaborate on the most important facets of implementation of teleradiology observed in the Indian context to help provide salient pointers to the readership of relevant jurisdictions who may be embracing comparable teleradiology challenges. Despite the hurdles, the future of teleradiology seems promising. The respective governments, policymakers and all relevant stakeholders must continue to take decisive action to ensure that this potential is fully exploited by allocation of necessary funds, strengthening of Information Technology and its related units, involvement of human resources with adequate technical and administrative expertise as well as take continued action to better existing telemedicine and teleradiology services.

Introduction

The field of teleradiology has been a matter of interest for nearly 55 years and constantly evaluated and explored for its potential prospect in healthcare [1,2]. However, teleradiology cemented its place only in the 1990s after the American College of Radiology (ACR) defined it in *ACR Standard for Teleradiology* as: "Teleradiology is the electronic transmission of radiological images from one location to another for the purposes of interpretation and/or consultation. Teleradiology may allow even more timely interpretation of radiological images and give greater access to secondary consultations and to improved continuing education" [3].

The emergence of teleradiology, hence thereafter acted as an important nidus in the overall growth of the domain of telemedicine around the globe. The ongoing Coronavirus disease

2019 (COVID-19) pandemic has further exponentially accentuated the need for telemedicine and teleradiology given the globally advocated preventive measures such as social distancing and hand hygiene.

Ever since COVID-19 was declared a global pandemic by the World Health Organization on March 11, 2020, it has disrupted routine healthcare practise and has brought about ever-increasing challenges for the healthcare industry. Even amidst the unfavourable circumstances, health care professionals as well as other allied stakeholders have rapidly responded to better understand the disease and develop systems to effectively diagnose and treat patients. Embracing teleradiology and telemedicine especially by developing countries like India is one such excellent example portraying resilience and adaptability.

The Indian government has proactively taken multiple measures to slow down disease progression and spread. "eSanjeevani", is the first of its kind, free of cost, largescale telemedicine initiative in India, developed indigenously by the Health Informatics Group in Mohali branch Centre for Development and Advanced Computing (C-DAC). Government of India's 'eSanjeevani' telemedicine initiative is serving patients through two variants namely - doctor to doctor [eSanjeevaniAB-HWC (Ayushman Bharat-Health and Wellness Centre)] and patient to doctor [eSanjeevani OPD (Out Patient Department)]. 'eSanjeevaniAB-HWC' operates and is based on a Hub-and-Spoke model with the aim to provide general as well as specialised health care services to populations and communities residing in rural areas and isolated regions by exploiting the potential of information technology to overcome barriers such as geography, accessibility, and financial burden. 'eSanjeevani AB-HWC' enables interconnection between the beneficiary (along with a paramedic and a generalist) at the spoke, with the HWC and the doctor/specialist at the hub (tertiary healthcare facility/hospital/medical college) helping facilitate real-time virtual consultation. The national telemedicine service is continuing to gain popularity amongst physicians and patients alike across the country. 'eSanjeevaniAB-HWC' is functional at over 50,000 Health and Wellness Centres as spokes and these spokes are being served by medical officers, specialists and super-specialists seated in over 2000 central hubs. The other variant 'eSanjeevani OPD' was rolled out on 13th of April 2020 and is aiding in the delivery of health services to patients in the confines of their homes through online OPDs, which include specialty and super-specialty online OPDs [4]. Incentives for participating doctors are paid by some states after verification of records and performance. Over one hundred thousand doctors and health-workers across

the country have been educated and trained through several modalities which include hands-on training through audio-visual aid by relevant authorities and technicians as well as release of the comprehensive "Telemedicine Practice Guideline" in March of 2020 by the Medical Council of India and Board of Governance in partnership with NITI Aayog (National Institution for Transforming India). The trained personnel were then onboarded to serve the beneficiaries on the National Telemedicine Service (NTS) [4,5]. As of 25th March 2022, Health Ministry's eSanjeevani has completed over 30 million telemedicine consultations. The NTS is additionally operational with an impressive 99.5% uptime and is currently exploring Artificial Intelligence (AI) interventions to further increase the efficacy of the initiative [4].

On a similar front in the context of efforts taken to implement teleradiology in India is the CollabDDS Online Radiology Services (CORS) initiative. It is a web-based interface that provides an integrated online environment between remote health centers with expert radiologists and doctors in tertiary healthcare facilities to visualize and study radiological images in real-time. CollabDDS was an outcome of a model project funded by the National Knowledge Network (NKN). The high-bandwidth and low-latency capability of the NKN is believed to provide an ideal platform for data transmission of large sized radiological data [6,7].

States and Union territories in lieu of the COVID-19 pandemic are constantly working towards further bolstering infrastructure and healthcare setups required to practice and effectively employ telemedicine and teleradiology at all levels.

Merits of Teleradiology
Teleradiology is a lifesaving technology in a country as densely populated as India, with a highly skewed doctor-to-patient ratio where radiologists are frequently fragmented [6]. Teleradiology is therefore a promising modality which would make it possible to provide radiological services to even the most remote areas in the country.

The ease of enrolling tele-radiologists can address short term staff shortages. Current level of internet connectivity has enabled telemedicine solutions to be implemented in most urban areas with substantial progress being made in its setup and growth in other relatively poor regions in India. Expense of running a telemedicine centre is far lower than running primary health care facilities with specialised services for a similar population coverage, thus

reducing the economic burden for a majority of the parties involved [8]. As a result of the COVID-19 pandemic many radiologists as well as hospital administrations in India have embraced teleradiology to help minimize physical interaction with the patients which has aided in decreasing the spread of SARS-CoV-2 especially in healthcare settings. India's launch of the COVID-19 test bus based upon indigenous technology has been facilitating inexpensive and rapid testing of inhabitants in densely populated urban areas whilst protecting Healthcare workers from untoward exposure by implementing onboard low dose digital X-ray services alongside real-time teleradiology [9]. Teleradiology could also help bridge the gap in providing equitable access to diagnostic imaging in developing countries. It may be the most practical solution to dealing with the shortage of on-site experienced radiologists helping provide accurate as well as timely diagnostic, prognostic and therapeutic consultation which could prove lifesaving to a majority of the population with relative ease.

Pitfalls of Teleradiology

Poor telecommunication facilities in India with unreliable telephone lines and poor digital exchange, especially in rural areas, are a significant hurdle to all forms of telemedicine. The cost of transferring images from remote rural areas to bigger cities with access to radiologists is high due to slow dial-up internet in such secluded areas [10]. The larger the image size, the higher the quality and better suited it is for radiological diagnoses. However, this also increases the cost of transferring images from one computer to another, influenced by device memory, internet speed and type of internet (dial-up vs. high bandwidth network services) [11].

Since digital images usually utilize more space, the need for image compression emerges. Image compression is classified into two types: Lossy or irreversible compression and lossless or reversible compression. In lossless compression, the compressed image can be recreated and restored to the original image without distortion at any time. Losing minute image details might result in missing a pathology which could drastically change the diagnosis, resulting in critical individual and legal consequences [11]. There is a complete lack of expertise about image compression among most medical professionals. This dearth of knowledge is even more evident in rural areas of India, where primary care physicians would be operating at the grassroot levels of the teleradiology network. Unless proper training is provided to doctors (both primary care and radiologists), manual errors can lead to significant liability. Senior physicians' limited understanding of telemedicine technology creates a steep

learning curve before effective teleradiology services in India can be realized. India being a developing country, most hospitals are hesitant to get involved in teleradiology projects due to the unrealistic pricing of teleradiology packages by vendors [10]. Furthermore, reports of extremely long waiting times by patients on the 'eSanjeevani' telemedicine platform in India may be attributed due to shortage as well as unavailability of doctors [12]. Another cause for concern in the successful adoption of the 'eSanjeevani' telemedicine initiative in the Indian sub-context includes potential abuse of the platform as registration does not require any proof of identity. The current registration is a 2 step process wherein, the first step involves one-time password authentication and the second step requires filling of personal identifiable information. However, abusers may misreport their details and there currently exists no robust system in place to trace the individual [12].

The burden from administrators for whom teleradiology projects are profit-making investments would reduce communication with patients and colleagues. This could lead to feelings of isolation among radiologists. The ever-rising workload could culminate in a lack of enthusiasm among such practicing physicians. Moreover, most patients demand one-on-one interaction with their radiologist to interpret complex medical jargon of imaging results which is often lacking in teleradiology [13].

The pandemic has further increased the need for efficient telemedicine and teleradiological services in India. However, without a steady and sturdy base which include a strong Information Technology (IT) infrastructure, remote and secure connection to electronic health records (EHRs) or hospital information systems (HISs); a widespread network of teleradiological services cannot be set up in the country at such short notice [14].

Future Perspective

There is a serious scarcity of radiologists in India, and therefore it's critical to increase the use of teleradiology across the country to enable for early diagnosis, particularly in emergency situations. Similarly, there exists extensive shortages of imaging resources as well as workforce in several low- and middle-income countries (LMICs)[15]. Outsourced teleradiology is becoming more popular, but quality and technical innovation must always be prioritized [16]. With the increased demand for radiologists around the world, the need for outsourcing teleradiology has significantly increased and is expected to further grow exponentially in the years to come. The advent of the cloud environment and cloud-based

collaboration tools has been the most inventive technological phenomenon in the recent past with promising updates and developments that are being continually seen aiding the process and trend of teleradiology outsourcing. The ability to upload, retrieve, and store radiological images, reports, and other data on these virtual centres has resulted in significant cost savings. Reduced costs of infrastructure and easy access by authorized radiologists are some of the few key advantages of cloud-architecture, making it one of the few invaluable and pivotal tools in the growth of teleradiology. To improve radiologists' productivity and quality of life, the teleradiology outsourcing market has been gradually adopting modern and efficient workflow management systems, such as the Picture Archive and Communication System (PACS), the Digital Imaging and Communications in Medicine (DICOM), and Radiology Information System. The add-on features and collaboration options made available through these systems are enabling seamless communication and data flow between hospitals/diagnostic centres, clinicians, and radiologists. Many businesses, including teleradiology, have also immensely benefited from artificial intelligence (AI). In the years to come AI will most definitely prove to be a decisive entity in the growth and betterment of teleradiology through enhanced and relatively accurate interpretation of radiological findings probably even without the need of radiologists. It must however be borne in mind that expert consultation of radiological images by experienced radiologists will always be pivotal given the multitude of factors influencing the final interpretation of images such as clinical co-relation, processing errors, faulty or modified imaging techniques among others which could produce inconclusive results if processed by AI. AI can also serve as a virtual assistant to the teleradiologist helping improve the quality of the reads.

The recent exciting advancements in technology such as the use of mobile phones and tablets further enhance the delivery of teleradiology, and are set to grow in utilization, especially with the rapid adoption of technological advancements by upcoming radiologists. Continuing medical education in the field of radiology is critical even during the COVID-19 pandemic to keep remote personnel up to date on new processes and practices in order to strengthen and enhance their knowledge. The field of teleradiology is becoming vast and complex. To keep pace, radiologists need to receive adequate specialized training in the use of the most recent versions of digital technologies, such as PACS, DICOM, and voice recognition. This trend is currently nascent in India. Furthermore, teleradiology can help in increasing exposure to clinical subspecialisations, such as neuroradiology, paediatric radiology and others to help

develop a more enhanced learning experience providing a broader and deeper knowledge base in the field of radiology [16].

Teleradiology and AI are synergistic in terms of their potential to impact healthcare delivery in the future [17]. Teleradiology training is proposed to improve the skills of rural healthcare professionals operating in primary healthcare settings that use eHealth systems [18].

Conclusion

Steps must be taken to allow teleradiology to flourish especially amidst the crises caused by the COVID-19 pandemic. Transition of all operative areas to a full teleworking experience is not without its own set of challenges especially in a developing country like that of India. Similar challenges continue to also be faced by several other developing countries across the globe. These developing countries can use the ongoing Indian teleradiology experience to better equip and adapt themselves by learning from its ups and downs to aid in better implementation of teleradiology initiatives in their own counties. The respective governments, policymakers and all relevant stakeholders must continue to take decisive action to ensure that this potential is fully exploited by allocating necessary funds, strengthening Information Technology and its related units, and involving human resource with adequate technical and administrative expertise. In addition, implementation of measures such as reimbursements and financial incentives to avail and/or support teleradiology services will further aid in its overall growth. Steps must also be taken to spread awareness about health related teleconsultation services to the public and the healthcare sector alongside provision of basic training to aid in the effective usage of the platform. However, the future in the field of teleradiology is promising with the ever-increasing availability of more affordable and faster wireless data transfer, mass storage options, and broadband cellular technology; ergo, teleradiology is en route to changing the paradigm of radiological practice in the years to come.

Abbreviations

AB-HWC: Ayushman Bharat-Health and Wellness Centre

ACR: American College of Radiology

AI: artificial intelligence

COVID-19: Coronavirus disease 2019

DICOM: Digital Imaging and Communications in Medicine

NKN: National Knowledge Network

NTS: National Telemedicine Service

OPD: Out Patient Department

PACS: Picture Archive and Communication System

SARS-CoV-2: Severe Acute Respiratory Syndrome Coronavirus 2

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