Image quality in telehealth: challenges in developing countries

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Abstract

The purpose of this paper is to explore the underlying challenges in the telehealth environment in India and Pakistan that impede the delivery of high-quality images between a patient and health care professional. An exploratory study was conducted among healthcare professionals in India and Pakistan to assess their perceptions regarding image quality, which is used for the diagnosis and treatment. This cross-sectional qualitative study used semi-structured interviews with healthcare professionals in both India and Pakistan. The interviews were analyzed using a thematic analysis, which revealed three major themes. These themes being: ICT infrastructure and connectivity, high-quality images were produced by trained technicians in an organized telemedicine set-up; and image quality can be degraded by multiple transmissions. Findings indicate that in both countries the main underlying challenge is the lack of consistency in the network infrastructure between urban, rural and remote areas. Additionally, training patients to use hand-held devices to take high-quality images future could hold the key to improving the reliability and consequently the quality of images transmitted between patients and health care professionals.

1 Introduction

Image quality in providing telehealth services is an ongoing concern within the healthcare domain [1, 2]. In recent years, there has been an increased interest among healthcare professionals to provide telediagnosis services [3–5]. Telediagnosis may involve direct interaction with the patients, or it might be a collaboration between healthcare professionals [6]. As such, real-time transmission of high-quality medical images, graphics and video is a pre-requisite to achieve this goal. Apart from organized telemedicine services, healthcare professionals use the benefits of social media and messaging tools to receive reports, images, and videos, either to deliver consultation to the patients, or to seek expert opinion from another healthcare professional. These types of online consultations may be the initial contact between the patient and the healthcare professional or it may be a follow-up consultation. Thus, it is evident that to enable the transmission of high-quality images, graphics and videos and to handle the large amount of data generated, it is essential to have high-bandwidth network infrastructure. This paper identifies the perceptions of healthcare professionals in India and Pakistan regarding the challenges associated with the quality of medical images, graphics and videos used for diagnosis and treatment of patients.

2 Literature Review

Within India and Pakistan, there are several challenges associated with the face-to-face delivery of healthcare. These include; substantial distances between patients and the nearest healthcare services facility and geographical and topography barriers in some regions [7,8]. Furthermore, there is a shortage of healthcare professionals in some rural and remote regions [9,10]. One possible solution to address these challenges is the use of technology to conduct live, interactive consultations between primary care

physicians, allied health professionals and patients and to transmit medical images and graphics to health professionals for diagnosis [11].

This paper addresses a gap in the current literature as there is a paucity of research on the perception of Indian healthcare professionals regarding the quality of images transmitted in the telehealth environment and the viability of image transfer for medical consultations. This is despite previous studies indicating that interest in telemedicine is high in both health professionals and students [12,13].

A review of the literature reveals that several specialized medical areas, including dermatology, ophthalmology, radiology, and nursing have benefitted from image transmission via mobile devices [1,2,14-17]. It is also evident that mobile phone technology has been used to transmit digital images from neurosurgical patients to health professionals, resulting in informed decisions being made about patient transference to specialized facilities [18]. Additionally, research has identified that the removal of blocking filters on mobile phone cameras enable these devices to use near infrared imaging to improve the quality and validity of images for diagnosis purposes [19]. In India, satellite-based screening for retinopathy has been recommended, however, the viability of using such systems remains problematic due to the inconsistency of broadband delivery across the country [20]. It is evident that in both Pakistan and India, there is a similarity of challenges faced by the healthcare sector associated with the reliability of the countries ICT infrastructure [7,9,21-24].

There have been a range of studies, conducted in India and Pakistan regarding the adoption of ICT within the healthcare domain [25-36]. Chandwani, Dwivedi [37] suggested challenges in the adoption of telemedicine can be classified across policy, societal, institutional and medical infrastructural levels. Elder, Clarke [38] identified that the specifics of the local environment had to be acknowledged when conducting research on the adoption of ICT within healthcare, as each environment has its own unique challenges. It is also evident that different cultures within countries may respond differently to the adoption of technologies for primary health care [39].

Within Australia, Carati, Margelis [40] suggested that barriers and enablers be identified in order to maximize the locus of telehealth implementation. Further, Dodel [41] suggested the need to construct cost-effective, quality research instruments and to test the ICT assets of access, usage and appropriation as independent variables in further studies on the adoption of ICT within healthcare. Recently the development of a conceptual framework, designed to guide research within the Indian telehealth environment identified that image quality and the network infrastructure were significant determinants in the adoption of telehealth by healthcare professionals [29].

Other determinants that have an impact on the adoption of telehealth in India and Pakistan include accessibility to healthcare professionals, the quality and reliability of the ICT infrastructure within a region, the shortage of healthcare professionals in rural and remote locations, patient education regarding the benefits of telehealth, patient demographics and technology safety and awareness [3,26-31,21,42-44,32,45,46]. This research focuses on one specific determinant, the quality of images

transmitted within the telehealth environment in India and Pakistan, as it is evident, from a review of the literature that scant studies have been undertaken on this topic.

3 Methodology

The aim of this research was to gain an understanding of the challenges affecting the quality of images used by health care professionals for diagnosis in India and Pakistan. This small-scale, exploratory qualitative research was conducted using in-depth semi-structured interviews with a range of health care professionals in both India and Pakistan, to collect their perceptions about the quality of images transmitted within the telehealth environment. Doctors and other allied healthcare staff were interviewed with their responses being recorded. A manual thematic analysis [47] was conducted to analyze the healthcare professionals narratives so as to identify, evaluate and report themes regarding the image quality within the telehealth environment. Ethics approval to conduct this research was obtained from the relevant authorities prior to conducting the interviews.

3.1 Design

The design of the research was exploratory in nature, reflecting the paucity of information on this topic [48]. Semi-structured interviews were selected as they enabled the researcher to prepare questions prior to the interview. They also enabled the participants the freedom to express their individual opinions and provided reliable, comparable qualitative data [49]. Additional considerations for selecting semi-structured interviews instead of focus groups included outreach and costs. Constraints associated with focus groups, including finding a convenient interview time, participants not willing to contribute their opinions, participants being under pressure to concur with the dominant views and the results being difficult to analyze were avoided [50]. Additionally, the costs of gathering participants together for a focus group were reduced as interviews were conducted with each participant either face-to-face or via a telephone.

3.2 Qualitative data collection

Cross-sectional data collection was used in this research [51–53], with 11 semi-structured interviews being conducted between February 2019 and June 2019 with health professionals located in India and Pakistan. The Head of each healthcare department was contacted prior to this research occurring. They authorized this research being undertaken in their workplace and assisting in organizing the written consent of each participant. The site of each interview was decided prior to the interview taking place and was mutually agreed upon. Sites included the healthcare professionals' workplace or where appropriate and convenient, via a telephone conversation. Each semi-structured interview was audio recorded to enable translation of the conversations into text for analysis.

The participant healthcare professionals were situated in the Punjab state (four participants) in Pakistan and in the Indian states of Uttar Pradesh (three participants), West Bengal (one participant), Maharashtra (two participants) and Tamil Nadu (one participant) and all were involved in providing a range of

telehealth services. Random convenience sampling was used for selecting the participants based on ease, accessibility and low costs [54, 55]. Seven participants were males and four were females. Among the healthcare professionals eight were doctors, two were dietitians, and one was a healthcare administrator. Four of the participants were involved in primary care telemedicine and seven were involved in medical advising through an online medium.

A pilot study was conducted by considering the initial four interviews to test and confirm the reliability and validity of the questions and respective dataset [55, 56]. The interview questions were refined accordingly after the pilot study.

4 Analysis, Findings And Discussion

The initial phase of data analysis involved the transcription of the recorded data to written data by the researchers. The researchers elected not to use computer aided software to assist with the transcription as, although it is faster, the researchers wanted to become immersed in the data and get a sense of the whole interview prior to commencing the initial search for themes [57,55]. An inductive thematic analysis was applied to the transcribed data as it enabled the researchers to identify and develop themes via iterative readings of the transcripts [58,59].

Three main themes, associated with image quality, emerged from the analysis of the transcripts. These themes were:

- The infrastructure and connectivity within countries affected the image quality.
- Images taken by tele-health professionals are superior to those taken by the patients on hand-held devices.
- Transmission of images between health-care to health-care professionals can result in degradation of the quality of the image.

Infrastructure and Connectivity

Two different themes, both associated with ICT, emerged from the data collected. The participants situated in Pakistan identified that that main issue with image quality was the inconsistency in the infrastructure between institutions. As there is no standard infrastructure used between telehealth facilities, the quality of the image can be affected. Participant P1 identified:

> The first thing is the infrastructure. The infrastructure should be there in all the institutions you want to involve patients and others for this purpose.

This was supported by participant P2:

> You can have very good internet facility in your center but the same sort of facility has to be available to the remote areas, only then you can deliver the services.

Within India the problem with image quality is the consistency in the connectivity of the broadband throughout the country. Participant I1 stated:

> Basic connectivity should be more robust. Instead of tower and cable based, satellite based broadband is required for much better service. The bandwidth needs increasing so there is an uninterrupted supply; a robust and steady bandwidth.

Further evidence of the issues associated with connectivity in India came from participant I3:

> The platform has to improve. In future it may be good for communication. Now it's not up to the mark, there is lots of scope for improvement. In our country we have to sit in a place where we can connect, we can't afford to walk and talk to a client.

Participant I7 said:

> The one-to-one connection in the virtual window needs to be improved. We also need to work on the platform. The challenges in the virtual platform are the ease of use and the network problems.

In another example, participant I6 said:

> First of all connectivity, it is not always seamless particularly in terms of voice connectivity as lot of people are using the same bandwidth. The quality of voice is poor and it getting worse, there is no point of having a good telephone and a bad line.

The connectivity specifically affects the use of digital equipment and the associated recorded image. Participant I1 said: "Configuring the digital instruments are a challenge due to the disruptions in connectivity".

As evident from the above excerpts, two related factors affecting the quality of images is the different infrastructures used by different telehealth set-ups and the connectivity in rural and remote locations, specifically in India. In Pakistan the telemedicine hubs located in urban hospitals have adequate broadband and ICT infrastructure. Similarly, the urban ICT infrastructure in India is robust, however, the connectivity in rural areas is inconsistent.

Expertise of person taking images

From analyzing the data, the second theme that emerged was the difference in the quality of the image depending upon who took the image. If the image was taken in an organized telemedicine set-up and handled by a trained technician, it was evident that the quality was first class which made for easier diagnosis by doctors and other health professionals.

Participant P1 said:

> There are conditions in which you can directly see the problem of the patient, you can ask to focus the camera on the problem, you can see problem, you can take the picture, you can get the reports online, and then you can tell the patients something about the treatment.

Participant P2 said:

> Our technical people they can make a very good audio-visual connection, so the image and audio-visual is very clear. We can watch everything on our screen, look at the CT scan images and ask questions which they can answer. They make a very good audio-visual connection.

Participant I2 agreed:

> If the health workers facilitates the interaction between the doctors and patient and sets up connected devices like digital stethoscope, patient examining camera and other things to measure blood pressure, hypertension, diabetes, random blood sugar fasting, oral cancer detection, the doctor can clearly see the issues, give advice and prescribe a treatment.

However, it appeared that in both countries there were consistent challenges associated with patients taking images of their health issues:

In Pakistan, participant P1 suggested that:

> There are so many challenges, which are related to knowledge of IT. The thing which is important is the availability of the gadgets, every second person is holding a smart phone, they can easily connect to many things, but these things need to be organised at higher levels so people at the lower levels can get the benefit. General education and knowledge is important.

The lack of education in using smart phone technology and transmitting images using different apps was evident in the responses of participant P3:

> A few of the patients, they are educated and we can give them the services. Using WhatsApp via the internet only a few people get the benefits as many of our patients cannot afford these services now. Only the educated patients can understand and know how to use them.

Participant P4 thought that the main issue when using smart phone technology was language based: ‘Some of the people in remote areas they can write in English with Urdu knowledge, but they can’t read English’.

In contrast, participant I4 thought:

> I think the majority of the people are illiterate, but they know how to use headphones, how to use mobiles, it would not be difficult to train these persons regarding using them for telehealth.

Participant I6 also agreed that training would assist in the use of smart phone technology for telehealth imaging; “I think training is useful, very useful, but that has to go with good quality technology as well”.

The issues associated with the patient using a smart device to take images appears to be the lack of knowledge regarding the use of different apps both to take the image and to transmit it to health-care professionals. Additionally, it is not evident that there is any consistency in the type of app that is preferred by health-care professionals for image transmission. Connectivity and the ease of use by the patient are the two main criteria by which apps are selected. Participant I5 said:

> Skype has some sound issues. I use Appear.in which has good connectivity and no sound issues. Patients do not have to log in which is an advantage for the non tech-savvy patients. It has a virtual video room where the doctor-patient can interact and images can be observed.

The selection of app to use for best interaction between the client and health-care professional was supported by participant I7:

> We need to have video conferencing, they have a much better connectivity and feel when compared to the small apps such as video chat. Using video conferencing systems such as Zoom we get better connectivity.

The importance of the quality of the image received by the health-care professional was highlighted by participant I3 who said:

> We are judging by pictures only. The picture quality matters as on-line consultations are only in 2D whereas in physical/face-to-face consultations you can see everything in 3D.

Participant I2 mentioned that the transmission of images was:

> A lifestyle changer, not only for medicine, but pictorials, multimedia, films can be sent over the internet and seen on the computer. The challenge is that human resources are required to run this technology effectively and efficiently with focus and institutional interest.

The findings indicate that high quality images are important when diagnosing conditions. Images taken and transmitted are of higher quality than those taken by patients using handheld devices. The lower quality images taken by patients appear to be the result of clients being uneducated in using apps on handheld devices and the inconsistency in the apps used by different healthcare set-ups. All healthcare professionals interviewed agreed that the quality of the image was extremely important in determining the issue and diagnosing treatments.

Health-care to health-care transmission of images

The third theme evident from the analysis of transcript interviews was the transmission of digital images to other doctors and specialists to get a second or expert opinion. If the initial image quality is poor, it is

difficult for specialists and doctors to make an evidence-based decision or determine appropriate treatment.

Participant P1 talked about the convenience of using digital images to get a second opinion:

> I have a patient over there, this happens to me every day or every other day. I see that patient and I seek another opinion. I need the opinion of some other person, so I will take the picture and send it on WhatsApp to the other person. I will then call him, give him the history of the patient, what my findings are and ask him to give me their opinion.

Participant P2 said:

> We use them as experts, calling them and sending them data to look at and give their expert opinion. Even during operations, the surgeons need consultation. I used to call my professor and share my findings for expert opinion. If I can take a picture and send it through WhatsApp then the professor can advise me of the next steps after watching the pictures.

As most of the healthcare professionals work in an organized telehealth set-up the transmission of images between them for expert opinion depends upon the organizational ICT infrastructure. Images are frequently transmitted for expert opinions and any degradation in the image, through compression of photos, distortion from device-to-device or unreliable infrastructure can affect the quality of the image.

5 Limitations

These findings are based on a small number of interviews of healthcare professionals in a few states in India and Pakistan. In future studies the findings need to be generalized over a large population of healthcare professionals throughout both the countries.

6 Conclusion

This research study was conducted in India and Pakistan to uncover the perceptions of healthcare professionals regarding the quality of medical images transmitted and the viability of such images within telehealth set-ups.

Three main themes emerged from the research:

- The infrastructure and connectivity within countries affects the image quality.
- Images taken by tele-health professionals are superior to those taken by the patients on hand-held devices.
- Transmission of images between health-care to health-care professionals can degrade the quality of the image.

The principal findings of the research identified that the ICT infrastructure of both countries needs to be further improved to enable consistency in the quality of digital images across states and within telehealth organizations. It is evident that city and urban areas in both countries have more reliable ICT infrastructure and connectivity than those found in rural and remote regions. Given that one of the aims of telehealth is to diagnose and treat patients who live in these regions and who are not able to travel to cities and large towns, the unreliability of ICT inhibits both the transmission of quality images to telehealth centers [8,10,25,27] and the transfer of images between healthcare professionals. Finally, the improvement in hand-held devices can be seen as a major driver in improving the image quality sent by the patients to the doctors [60], however, lack of patient knowledge of how to use the inbuilt camera and different apps for transferring digital images greatly decreases the quality of the images when compared with those taken by health care professionals. Further training and education of clients in using hand-held devices is recommended to enhance the image quality.

Declarations

Ethics approval and consent to participate

The research has full ethical approval of the University of Southern Queensland's Human Research Ethics Committee. The approval number is H18REA086.

Consent for publication

Not Applicable

Availability of data and materials

The datasets generated during and/or analysed during the current study are not publicly available due to the data being non-identifiable as per ethics approval but are available from the corresponding author on reasonable request, as per University of Southern Queensland's research data policy and approval.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

AC: Conception and design; Data Collection; Manuscript Writing; Final Approval of Manuscript

AHB: Conception and design; Data Collection; Manuscript Writing; Final Approval of Manuscript

RG: Conception and design; Data Collection; Manuscript Writing; Final Approval of Manuscript

AM: Conception and design; Manuscript Writing; Final Approval of Manuscript

MAS: Data Collection; Final Approval of Manuscript

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