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RESEARCH ARTICLE

THE ROLE OF TELEMEDICINE IN REMOTE PATIENT MONITORING: A REVIEW OF CLINICAL TRIALS AND TECHNOLOGICAL INNOVATIONS

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ABSTRACT

Telemedicine is the practice of delivering healthcare remotely via the use of technology, allowing for direct communication between patients and healthcare professionals as well as the exchange of medical records without the necessity for face-to-face encounters. On the other hand, remote patient monitoring (RPM) entails continuously tracking patients' health information and vital signs utilizing a variety of digital tools and technologies. This divide is filled by telemedicine, which enables patients to digitally communicate with medical professionals wherever they may be. For elderly or underprivileged patients who are confined to their homes due to chronic illnesses, telemedicine technology can be used to offer home health care. In a number of recent randomized controlled studies, RPM was discovered to be more effective than traditional treatment. Virtual reality and augmented reality, particularly in the context of telemedicine and RPM, have profoundly changed the landscape of healthcare. Even though telemedicine has many benefits for monitoring patients from a distance, it is important to understand and deal with the obstacles and drawbacks that might hinder its efficacy and uptake. Beyond its technical capabilities, telemedicine's effectiveness in remote patient monitoring depends on the experiences, viewpoints, and input of both patients and healthcare professionals.

INTRODUCTION

In recent years, the landscape of healthcare delivery has witnessed a transformative shift with the advent of telemedicine (TM) and remote patient monitoring (RPM). Telemedicine refers to the use of technology to stipulate healthcare services remotely, permitting patients and healthcare providers to communicate and exchange medical information without the need for in-person visits. Remote patient monitoring, on the other hand, involves the continuous pursuing of patients health data and vital signs using numerous digital devices and technology. Although telemedicine is frequently used interchangeably with the term "telehealth," the latter really refers to a broader range of healthcare services, including those delivered by pharmacists and nurse practitioners in addition to doctors. It could also comprise administrative or public health services related to healthcare or clinical care, as well as education for patients and healthcare professionals.

The United States (US) Department of Health and Human Services defines telehealth as the "use of electronic information and telecommunication technologies to support and promote long-distance clinical health care, patient and professional health-related education, public health and health administration".⁽¹⁾ The Agency for Healthcare Research and Quality divides telehealth into three distinct groups like storing and forwarding telehealth, which encompasses the sharing of medical imageries or data amongst providers; home monitoring telehealth, also known as remote patient monitoring, which involves using telehealth to tenuously monitor patients and their health status. Typically, telehealth comprises the delivery of long-distance or remote healthcare through electronic consultation and information technologies.⁽²⁾ Whereas the word telemedicine is more frequently used for healthcare purposes, such as providing medical care to patients, whereas telehealth is used for both clinical and nonclinical uses. Telemedicine is defined as "the delivery of health care services where distance is a critical factor by health care professionals using information and communications technologies for the exchange of valid information for the detection, treatment, and avoidance of disease and injuries, research and evaluation, and the

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continuing education of medical professionals, with the aim of improving the well-being of humans" in the World Health Organization's Worldwide Strategy on Digital Health 2020–2025. Internet, store-and-forward imaging, video conferencing, streaming media, wired and wireless connectivity, and other techniques are included in telehealth.^(3, 4) Telemonitoring, another name for remote patient monitoring, is a cutting-edge approach to improving patient management and care as well as patient management and health. The implication of telemedicine and RPM has become particularly pronounced in scenarios where patients are geographically isolated from healthcare facilities, face mobility challenges, or require consistent monitoring for chronic conditions. Clinical feedback is provided via the digital transmission of the patient's physiological and disease-related data from their home to a medical facility. It enables early illness decompensation diagnosis, enabling early therapies, reducing mortality and inpatient stays, and enhancing patient education and self-management. By reducing the need for physical hospital visits and streamlining healthcare delivery, telemedicine has the potential to lower healthcare costs for both patients and healthcare systems. This financial relief can be especially impactful in resource-limited settings and for individuals who require ongoing medical attention. Since technology has experienced so many changes, telemedicine is now widely used. Intelligent sensors, wearable or handheld devices, cell phones with Internet access, and implanted monitoring gadgets are all commonplace in today's world. Remote patient monitoring helps to shifting the burden of care to the patient's home also facilitates supported self-care, giving the patient enhanced sovereignty and control of their health care. And has proved promising in the management of chronic disorders like diabetes, cardiovascular disease, and many more.⁽⁵⁻⁸⁾ There are certain things that could make telemedicine more difficult. The belief that telemedicine is excessively expensive is the biggest barrier to the introduction of programs around the world. Resources like as prohibitive costs for instruments, inadequate infrastructure, and a lack of technical experience are more frequently seen as obstacles to telemedicine in developing nations. Highly developed nations are more probable to see obstacles to the introduction of telemedicine as conflicting health system goals, legal concerns around patient privacy and confidentiality, and a perceived lack of demand.^(3, 5)

Benefits of Telemedicine in Remote Patient Monitoring:

Telemedicine has emerged as a game-changer in healthcare, particularly in the realm of remote patient monitoring (RPM). When consulting with patient, it is always good to have a family member who can help the patient to provide information, ask questions and take note of healthcare practitioners answers. Even if that member lives out of town, or even across the country, telemedicine can loop patients family member in on the virtual visit if patient choose. This can help to patient to get decent caretaker at home. One of the foremost advantages of telemedicine in remote patient monitoring is its capacity to overcome geographical barriers. Patients residing in rural or underserved areas often face challenges in accessing quality healthcare due to the lack of nearby medical facilities. Telemedicine bridges this gap by enabling patients to connect with healthcare providers virtually, regardless of their location. This increased accessibility is pivotal in ensuring that individuals receive timely medical attention and monitoring, even if they are situated far from healthcare centres.⁽⁹⁾

Moreover, telemedicine contributes significantly to the reduction of healthcare costs. Traditional in-person medical visits can be time-consuming and costly, not just for patients but also for healthcare systems. With telemedicine, patients can participate in virtual consultations, eliminating the need for travel and associated expenses. Additionally, healthcare facilities can optimize resource allocation by focusing on patients requiring physical presence while remotely monitoring others. This streamlined approach can lead to cost savings and more efficient healthcare delivery.⁽¹⁰⁾ In the context of remote patient monitoring, telemedicine's real-time data collection capabilities are emphasized. Patients equipped with wearable devices and connected healthcare tools can reveal vital signs, health metrics, and other relevant data to healthcare practitioners and paramedics without leaving their homes. This continuous flow of information encourages healthcare professionals to intently monitor patients with chronic conditions, detect early signs of deterioration, and intervene promptly. Consequently, patient outcomes can be significantly improved, as healthcare practitioners can initiate timely interventions that counteract complications and hospitalizations. Furthermore, telemedicine enhances self-management to get better health. Patients who actively participate in their healthcare journey through telemedicine are more likely to adhere to treatment plans, track their health metrics, and adopt healthier lifestyle habits.⁽¹¹⁾

Telemedicine and RPM in Clinical Trials: Clinical trials serve as essential pillars in establishing the credibility and effectiveness of telemedicine interventions for remote patient monitoring. These trials provide valuable insights into the impact of telemedicine on patient outcomes, healthcare delivery, and overall quality of care. Telemedicine technology can be applied to provide home health care for elderly or underserved, homebound patients with chronic illness. Instead of driving to far-off locations to check on recovering or persistently ill patients, it enables home healthcare practitioners to monitor patients from a central location. In case of elderly patients who are not familiar with mobile phones and communication networks, if a system is assembled that is comfortable for them to operate, RPM will be evenly operational.^(12, 13) RPM was found to be more successful than conventional therapy in several randomized controlled studies that were undertaken in the past at lowering the risk of death in CHF patients. With a mortality risk ratio of 0.66 in patients with CHF, RPM was successful, according to Inglis et al.⁽¹⁴⁾ who retrieved 11 papers from 1999 to 2009. Polisen et al.⁽¹⁵⁾ discovered that RPM was beneficial with a risk ratio of 0.64 after extracting five studies on RCTs and one observational study article from 1998 to 2008. Klersy et al.⁽¹⁶⁾ showed that RPM was beneficial with a risk ratio of 0.83 after extracting 19 publications on RCTs from 2001 to 2008.

A narrative synthesis and meta-analysis of 29 trials that assessed the effects of one or more forms of telemedicine treatments on HbA1c levels to standard care alone was done by Natalie Robson and Hassan Hosseinzadeh. The random effects meta-analysis's findings showed that telehealth treatments had a greater impact on HbA1c than standard care did. In people with Type-2 Diabetes, telemonitoring had a higher impact on reducing HbA1c levels.⁽¹⁷⁾ COVID-19 has disrupted oncologic care across the spectrum of cancer screening, diagnosis, and management.

Table 1. Telehealth Consent Teach-back Documentation for Obtaining Informed Consent.

If the patient able to teach-back the information in their own words make '☑' Yes, and if not then make '×' if No.				
	1st attempt	2nd attempt	3rd attempt	4th attempt
What telehealth is	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
What are the benefits of telehealth	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
What are the shortcomings of telehealth	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Privacy of telehealth (risks)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Replacement of office visit (options)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Facility to revoke consent with no penalty	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Obligation to sign (voluntariness)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Because of the COVID-19 pandemic, the conduct of clinical trials, especially patient enrolment, and monitoring, faces serious challenges, and concerns over the adverse impact on cancer outcomes and delays in getting new drugs to market and to patients are widespread.⁽¹⁸⁾ Oncology practices all around the United States have included telemedicine (TM) and remote patient monitoring (RPM) into normal treatment and clinical studies since the commencement of COVID-19. However, the extent of provider experience and comfort with TM/RPM in treatment trials.⁽¹⁹⁾ Remote patient monitoring (RPM) offers renal health care providers and patients with end-stage kidney disease opportunities to embrace home dialysis therapies with greater confidence and the potential to obtain better clinical outcomes.

The cost of delivery of care of home modalities in most countries is less than that of in-center haemodialysis. By using mobile phone Short Messaging Service, inexpensive digital cameras, and the cyberspace to address specific patient accessibility needs. By coupling those technologies with a dedicated Peritoneal dialysis team, it can be promising to develop a unique Peritoneal dialysis remote monitoring system. So that patients are always keep on in touch with their nephrologist, communicating in real time, around the clock, with improved Peritoneal dialysis outcomes, especially in rural patients.^(20, 21)

Obtain Informed Consent for Telehealth: The main intention of consent document is to provide information to patient. To obtain consent for telehealth it is important to send consent form in advance by mail or by using patient portal in advance, so that patient can review it prior to the discussion. By using the consent form as a checklist, it is necessary to conform all information discussed complies to the informed consent rules. And confirm patient understanding by using teach back method and document it as shown in Table 1. If patient ready to give consent mail them a copy of consent form to keep. To get a signed form from patient, use patient portal or the mail to get a signature.⁽²²⁾

Technology Innovations Driving Telemedicine: The landscape of healthcare has been significantly reshaped by technological innovations, especially in the realm of telemedicine and remote patient monitoring.

These innovations have revolutionized the way patients receive medical care, empowering them to actively participate in their health management and enabling healthcare providers to monitor and treat patients remotely. A key aspect of telemedicine's success in remote patient monitoring is the proliferation of advanced wearable devices and connected health tools. Wearable devices, such as smart watches, fitness trackers, and continuous glucose monitors, allow patients to track vital signs, physical activity, sleep patterns, and more. These devices offer real-time data collection, enabling healthcare providers to gain insights into a patient's health status between visits and to make informed decisions based on up-to-date information. Mobile applications also play a crucial role in facilitating telemedicine. Mobile apps allow patients to communicate with healthcare providers through secure messaging, video calls, and virtual consultations. These apps streamline the process of sharing health information, scheduling appointments, and receiving medical advice, all from the convenience of a smartphone. One method to speed up clinical communication among oral health experts and facilitate regular patient-doctor contact is to use WhatsApp and similar apps.

This should facilitate the timely, accurate, and effective therapy of oral diseases. Developments in remote monitoring technologies go beyond wearables and applications. Tools for remote monitoring include a wide range of gadgets that can keep track of health measures. For instance, glucose meters, pulse oximeters, and blood pressure cuffs with telemedicine capabilities can send information directly to medical professionals, allowing them to monitor patients' situations and take appropriate action as needed.⁽²³⁻²⁵⁾ Artificial intelligence (AI) and machine learning (ML) also have a substantial impact on telemedicine and remote patient monitoring. AI is the capacity of a computer system to do tasks in a way that is like how humans think, whereas ML is a branch of AI that focuses on how a computer naturally learns from data and becomes better over time without being explicitly programmed. These technologies can analyze large volumes of patient data, identify patterns, and provide predictive insights. AI-powered diagnostic tools can aid in the early detection of diseases, assist in image analysis (such as radiology and pathology), and enhance treatment recommendations based on personalized patient profiles.⁽²⁶⁾

Virtual reality (VR) and augmented reality (AR) are developing as cutting-edge telemedicine solutions that improve patient engagement and education. In the field of health care, VR and AR have been used for a variety of tasks, including robotic and laparoscopic surgery, post-stroke cognitive therapy, and surgical training. VR may be used to practice relaxation methods, educate patients about their diseases, and mimic medical settings. With the use of augmented reality, surgeons may execute difficult surgeries more easily and outside specialists can direct medical staff during crucial interventions. The use of ground-breaking technologies is more crucial now than ever before due to the coronavirus disease 2019 (COVID-19) pandemic. With its interactive capabilities, virtual reality (VR) may assist effective patient-centered rehabilitation and provide personalized care. It is a reliable and valid evaluation technique for figuring out balance, function, and joint range of motion in physical rehabilitation. It could make it feasible to personalize care, motivate patients, increase compliance, and monitor their progress. In pre-clinical studies, the use of AR supplements in orthopaedic surgery led to increases in surgical precision and repeatability, shorter operating times, and less radiation exposure. This may reduce the amount of labour that health care practitioners must do because minimal patient observation is necessary. It is frequently sold commercially and has the capability of being used for home-based therapy. (27, 28)

Challenges and Limitations for telemonitoring: While telemedicine possesses great promise in transforming healthcare delivery via remote patient monitoring, it is notable to acknowledge and address the challenges and restrictions that can accompany its realization. Understanding of these challenges is fundamental for devising effective tactics to overcome them and confirm the successful integration of telemedicine into mainstream healthcare practices. The digital divide is one of the main obstacles. The gap linking individuals with the most and individuals with the least intellect to information and communication technologies (ICTs) is generally referred to as the “digital divide.” Simply it refers to the uneven access to technology and the internet across different populations. Other measures of inequality including wealth, gender, race/ethnicity, and geography are most frequently linked to the digital gap. The bigger social worry is that diverse types of social, economic, and political marginalization will be made worse by a lack of knowledge about computers, the Internet, and associated streams of information. Patients lacking access to reliable internet connectivity or devices may be excluded from the benefits of telemedicine. Addressing this divide requires efforts to improve digital infrastructure and provide equal access to telehealth services. (29, 30) Telemedicine involves the transmission of sensitive medical information over digital channels. The triumph of telehealth could be dented if serious privacy and security risks are not tackled. In many cases, sensors are sited in a patient’s residence or that interface with the patient’s body to perceive safety issues or medical dangers may accidentally diffuse insightful information about household events. Providers and patients would lack confidence in the adoption of telehealth solutions because of the inadequate security and privacy measures for underlying telehealth data and infrastructure. Ensuring data security and patient privacy is essential to build trust in telemedicine. Health organizations must implement robust encryption, authentication, and privacy measures to safeguard patient data against breaches.

Also, there is not any federal agency that presently has the authority to authorize privacy and security obligations to shell the telehealth ecosystem.⁽³¹⁾ Telemedicine relies on remote communication, which causes a loss of personal connections and touch, which is believed to diminish the anticipated rituals that predictably consolidate the relationship between healthcare practitioner and patient. Telemedicine uses technology to stipulate healthcare services remotely, permitting patients and healthcare providers to communicate and exchange medical information without the need for in-person visits, which may lack the tactile and visual aspects of a physical examination. Healthcare providers must develop strategies to gather comprehensive patient information remotely and ensure accurate diagnoses. Telemedicine can lack the individualized touch and rapport established through in-person interactions. Healthcare providers must develop effective communication skills to build patient relationships virtually. Patient acceptance and adherence can be seen as a big challenge for the success of telemonitoring. Some patients may be hesitant to embrace telemedicine due to concerns about the quality of care, lack of face-to-face interactions, or unfamiliarity with technology. Ensuring patient education, training, and clear communication can help alleviate these concerns and improve patient acceptance. Sometimes patients may worry about inaccuracies in their care, healthcare practitioners pay less attention to them, it may be possible that they feel less comfortable while speaking up and asking queries, and may express some hitches establishing a relationship with healthcare practitioners. Certain medical conditions may require physical examinations, diagnostic tests, or procedures that cannot be conducted remotely. In telemedicine the diagnostic practices are mainly done by looking directly into the camera, there may be the probability of false diagnosis owing to gambles of instrumental errors. Telemedicine's suitability varies based on the type of medical issue and the necessity for physical assessment.^(32, 33) Technical glitches, such as poor audio or video quality during virtual consultations, can disrupt the telemedicine experience. Healthcare providers and patients need reliable technology platforms and technical support to ensure seamless interactions. There may be crucial technical problems related to the development of Web-based systems for telehealth applications. Cultural and language barriers are also a massive challenge in the viewpoint of telemonitoring success. Effective telemedicine requires clear communication and cultural sensitivity. Overcoming language barriers and ensuring culturally appropriate care is essential for delivering quality healthcare remotely.^(34, 35)

Patient and Healthcare Provider Perspectives: The success of telemedicine in remote patient monitoring extends beyond its technological capabilities; it hinges on the experiences, perspectives, and feedback of both patients and healthcare providers. Healthcare providers plays a pivotal role in the successful integration of telemedicine into remote patient monitoring. Telemedicine can enhance healthcare providers workflow by allowing them to allocate time effectively between in-person and virtual patient interactions. It saves time of healthcare practitioners and allows them to attend extra number of patients. Providers observe that telemedicine encourages patients to engage in their care by providing real-time health data and fostering better communication. Telemedicine platforms provide a medium for timely communication between providers and their patients, ensuring prompt responses to queries. Some healthcare providers may

express concerns about diagnosing conditions without physical examinations. Some complaints are exceptionally challenging to assess without a physical examination, like chest pain, abdominal pain, complaints with respiratory, headaches, musculoskeletal, or neurological indications. Sharing strategies for effective remote assessment can be beneficial. Apart from that technological proficiency is more challenging in telemedicine point of view. Providers may need training and support to become proficient with telemedicine platforms and tools. ^(11, 32, 36) Patients are at the heart of telemedicine's impact in remote patient monitoring. Patients appreciate the convenience of virtual consultations and remote monitoring, eliminating the need for travel and minimizing disruptions to their daily routines. Patients in rural or remote areas find telemedicine invaluable for accessing specialized care that might otherwise be unavailable locally. Some patients feel more at ease discussing their health concerns from the privacy of their own homes, leading to open and candid conversations with healthcare providers. Patients often report feeling empowered by participating actively in their health management through telemedicine. It is important to address any concerns patients may have about the quality of care, the absence of physical examinations and face-to-face interactions and data security. ^(32, 33, 35, 36)

CONCLUSION

Telemedicine exploits patient care and treatment efficiency. The benefits of telemedicine in remote patient monitoring are undeniable. From breaking down geographical barriers to reducing healthcare costs and improving patient outcomes, telemedicine has the potential to reshape the healthcare landscape. Clinical trials are the linchpin in validating telemedicine's efficacy and impact in remote patient monitoring. By examining the methodologies, results, and implications of these trials, understanding of the evidence-based support for telemedicine's integration into healthcare delivery. It underscores the transformative potential of telemedicine in revolutionizing remote patient monitoring and its broader implications for the future of healthcare. The integration of cutting-edge technologies into telemedicine and remote patient monitoring has expanded the possibilities of healthcare delivery. Wearable devices, mobile apps like WhatsApp, remote monitoring tools, AI, and VR/AR are driving this transformation, enhancing patient engagement, enabling remote care, and facilitating timely interventions. There are many technology-driven advancements in this field, which is supportive in shaping the future of healthcare and the potential of technology to revolutionize patient monitoring and medical care. While telemedicine offers numerous advantages in remote patient monitoring, it is essential to navigate and address the challenges and limitations that can impact its effectiveness and adoption. By recognizing these obstacles and devising strategies to mitigate them, healthcare systems can harness the full potential of telemedicine and ensure that it becomes an integral part of modern healthcare delivery.

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