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Telepresence Robots in Patient Care: Benefits and Challenges

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ABSTRACT

Telepresence robots are emerging as innovative solutions to bridge gaps in healthcare delivery, particularly for patients in remote locations or those requiring ongoing care. These robots enable clinicians to conduct remote consultations, monitor patient progress, and engage in therapeutic practices without requiring physical presence. This paper examines the benefits and challenges associated with the integration of telepresence robots into patient care. It discusses the types of telepresence robots, their applications in various healthcare settings, and the potential impact on patient outcomes, particularly in rural or underserved communities. While promising improvements in accessibility, efficiency, and patient engagement are highlighted, the paper also addresses the technical limitations, ethical concerns, and the need for further development of these technologies. The future of telepresence robots in healthcare is examined with a focus on evolving technologies, such as artificial intelligence and smart home integration, and their potential to transform patient care.

Keywords: Telepresence robots, healthcare delivery, remote consultations, patient care, robotics, healthcare technology.

INTRODUCTION

Care of individuals recovering from surgery or illness requires sophisticated support systems. Innovative work over the past two decades has demonstrated the utility of integrating advanced robotics with patient care. We now have the opportunity to use telepresence technology as an extension of this work. Several investigations are ongoing to measure the impact of telepresence robotics on patient outcomes and healthcare delivery. Studies in surgery telecare demonstrate the potential for a reduction in the need for in-office care. Telepresence technology has the potential to further improve functional status in post-surgical patients. Historically, devices have been built to bring some aspects of the clinician or activities in the office or hospital to the patient. However, complex and invasive treatments require frequent in-person provider assessment. Sophisticated telepresence robots are now being investigated to bring both the healthcare provider and the facilities that support care to the patient's home. Such technology is one way to help older adults receive care in the place they choose while addressing societal care providers' changing needs and perceived shortages. Technology needs to be user-friendly, unobtrusive and background-oriented. A lot of attention has been paid to diagnostic medicine, and one approach is the use of remote monitoring and virtual house calls. This paper addresses the use of remote encounters for treatment applications as much as traditional face-to-face office encounters. This balanced approach looks at the benefits and challenges of using telepresence technology in new and unique ways. The following telepresence systems are currently under investigation and will be described throughout the rest of this paper [1, 2].

Telepresence Technology in Healthcare

Improved healthcare accessibility depends not only on direct provision but also on practical solutions that provide expert care without some adverse effects of remote treatment. Early treatment can reduce the risk of chronic diseases and poor health conditions. Telepresence technology, and particularly telepresence robots, allows for human-to-robot presentation, doctor-to-patient treatment, and group-to-group treatment at a distance. The objective of this paper is to explore the effectiveness and opportunities brought by telepresence robots in remote patient treatment. The remainder of this paper is divided into

various aspects of telepresence robots: technology and applications, current trends, and benefits and concerns for telepresence care [3, 4]. Telepresence Robots The term telepresence robot refers to a mobile machine equipped with a video display screen and radio-operating buttons that allow an operator to communicate remotely by controlling audiovisual displays. The robots can be classified based on the working environment, movement, automation, or telecontrol. These robots are currently used as small servers that provide restricted patient care with improved patient response and medical staff and can sustain the health status of the local population in a simple solution [5, 6].

Definition and Types of Telepresence Robots

Telepresence robots serve as mobile, remote-controlled communication devices for clinicians employed within healthcare systems. The most advanced such robots offer video conferencing and command interfaces, in addition to a range of sensors, to coordinate with remote operator control to provide clinicians with the fullest possible sense of presence at the location of the robot. A range of telepresence robots exist, ranging from being primarily constant, stationary devices to highly mobile platforms designed for deployment and surveillance over large facilities or environments [7, 8]. Telepresence robots can be broadly classified into stationary telemanipulators, mobile telemanipulators, and hybrid devices. The different options reflect the progression of capability for these devices: while all stationary telepresence robots fall under the same general definition, for example, later advances in technology and control architecture led to the development of mobile telepresence and the hybrid combinations of these two basic forms. However, the shift in design from stationary to mobile platforms brings with it its own set of unique benefits and challenges. Several mobile and hybrid telepresence robots also provide additional sensors, manipulators, and/or interfaces, for example, to expand their use cases more generally beyond teleoperation by clinicians. Over the years, as computing, networking, and robotics have advanced, so too has the range of functions and operational scope for these devices. In recent years, larger healthcare systems have shown increasing interest in incorporating these robots into regular patient care workflows, and commercial options already exist from a variety of vendors [9, 10].

Applications in Patient Care

On a broader scale, telepresence robots can facilitate standard telemedicine applications, specifically remote consultation, usually in an asynchronous mode. This can be demonstrated, for example, to evaluate patients who present to a remote clinic or emergency department. It allows access to a specialist when a patient cannot afford or cannot travel to a tertiary care center or a referral center. The value of dedicated teleconsult programs has been suggested in controlled settings in diverse specialties like pediatric rheumatology, pediatrics, dermatology, otolaryngology, psychiatry, cardiology, diabetic retinopathy, radiation medicine, post-treatment survivors, and dietitian consultations. On a broader scale, telepresence robots have demonstrated value in ongoing extended ambulatory patient monitoring, for example, in patients undergoing therapy or rehabilitation or those in clinical trials. The social engagement potential of telepresence robots has demonstrated sustained use in ongoing child psychiatry trials [11, 12]. Part of the challenge is providing a service that offers an ongoing benefit that cannot be captured by a snapshot or a single inpatient consultation. Importantly, while occasionally teleconsults may suffice, most patients require physical examinations and some form of ongoing care or encouragement of physical activity or rehabilitation therapy. The scenario where the benefit of telemedicine is more pronounced is in remote and rural settings. Incorporating a device that is operated by the consulting investigator could add value by demonstrating engagement and possibly increasing motivation and adherence to home-based rehabilitation. The benefits of telepresence robots may be significantly more enhanced in children as well as in settings that demand prolonged periods of ongoing patient care, ongoing and repetitive duration gastropharyngeal physical therapy, or toxicology and accident and emergency scenarios where procedural sedation and sedated dentistry may be administered. There is superior safety with remote video monitoring. Patients must be monitored because of their varying and unstable neurologic status. While employed, the use of robots underscores the inequities of the standard of care and the need for the ongoing relevance of remote surveillance and management in poverty-stricken countries. Telemedicine comes with caveats, including ethical and data security issues. This must be adhered to in all robot settings, and a rigorous security model must be put in place. The role of ethics boards in robot and telemedicine experiments is gaining ground [13, 14]. Telepresence robots support continuous engagement with patients in a manner that is sensitive and accommodating to the diverse needs of different individuals while still honoring the principles of the standard of care and reducing burnout. They challenge us to go the extra mile, not least encouraging a principled 'can-do' approach and dispelling boredom. In addition, physicians armed with telepresence robots exemplify an

appreciative approach, working together with patients to develop personal and general virtues that resonate in private and public life. Collectively, telepresence robot-assisted healthcare reinforces the public importance of medicine and serves as a reference point for promoting the medical profession's standing in society. Telepresence robots could support broader integration in clinical practice [15, 16].

Benefits of Using Telepresence Robots in Patient Care

Several benefits are associated with employing telepresence robots in healthcare. The main advantages described focus on improved accessibility, engagement, and efficiency. Implementing remote consultations and examinations using telepresence robots may make healthcare services more accessible for people living in remote areas where healthcare professionals are less available. In addition to being available, healthcare providers may increase patient engagement, satisfaction, and perceived care personalization by allowing patients to conduct face-to-face consultations. Reducing patient waiting times in hospitals and physician offices is another potential advantage by reducing the number of no-shows for outpatient appointments conducted through telepresence robots. By testing novel, efficient telehealth programs, the technology has the potential to improve healthcare delivery while reducing costs [17, 18]. If telepresence robotics are cost-effective for treating chronic diseases, patients with these conditions may experience the greatest benefits. Remote monitoring technology and similar telepresence robotics reach more patients and provide care in a more timely manner, which can improve health outcomes. In addition, in practices with higher service demands, telepresence robots may provide valuable tools for meeting acute patient needs by increasing the availability of appointments. Telepresence robot technology can significantly increase appointment availability by increasing the number of visits per day scheduled, particularly for practitioners and therapists using the in-office robot. This means that the use of remote healthcare robots will allow some healthcare professionals to manage their overburdened schedules more effectively [19, 17].

Challenges and Limitations

Telepresence robots, with their current state of the art, can provide valuable services to medical professionals in patient care when various limitations and challenges have been taken into account. Telepresence stations are the most common way of employing telepresence robots. However, technological limitations, such as slow internet connectivity and the unreliable functionality of such systems, still exist, making telepresence robots less effective. Additionally, patient resistance to machines performing the treatment, loss of medical empathy, medical errors, and potential stiffness and awkwardness of movement could restrain the successful implementation of such robots [20, 21]. Robots and technology, in general, tend to gain resistance from healthcare professionals, have large investment costs, and may eventually fail for multifaceted reasons. Early investment in telemedicine and robotics would be justified from a societal aspect, but individual medical providers would not witness immediate personal financial benefits. The leadership of healthcare facilities would have to commit to risk-taking because they may be stuck with an expensive device, such as a telepresence robot if it turned out to be unpopular and was not used by patients. The protection of patient data is of utmost importance, and using telepresence robots to reach homes may cause security and privacy liabilities that must be strenuously addressed. Patients and designated helpers who control telepresence robots, along with the robot vendor, would be sharing the patient's most intimate data. Healthcare professionals are now sufficiently well-trained to use telepresence robots and telepresence technology, but continuing education would be mandatory. The training course would be slightly longer than the one to instruct patients on how to use the equipment. Telepresence robots fit resiliently into the environment of the emergency room, where they were initially developed. However, telepresence robots had not been initially designed to cope with the emotional atmosphere of policies in elder care homes or the trauma from major natural disasters [22, 20].

Future Directions

Several factors need to be considered in the future, which could help improve telepresence robots' effectiveness in healthcare. For instance, with an aging population, it is conceivable that the new fields of immunorobotics, neurorobotics, and connective technology will revolutionize healthcare. How telepresence robots could be enhanced regarding AI and other technologies and how these adaptable technologies can assist or augment these robots in the future are areas of potential exploration. Moreover, to make the robot applicable to home care, such robots could be coupled with ambient intelligence for enhanced perception, so that, for example, respiration, heart rate, and other parameters could be detectable. Such robots could potentially be used in the smart home of the future, easing the load on overstretched health and social care services and increasing patient quality of life [16, 23]. Researchers

and technologists could benefit by conducting research with frontline practitioners since the close-knit center will help to bring innovative ideas to the fore. The most pressing problems that need addressing include the development of a positive ethical framework surrounding telepresence robots that are free of discrimination. Additionally, suitable design principles should be adhered to create more socially and emotionally acceptable robots. Advances in the field of telepresence robotics and convergent technologies could bring tremendous benefits to society and the economy along with international recognition, and international and interdisciplinary collaboration is therefore recommended. Future research could address the lack of current evidence and aim to obtain the views of larger cohorts of healthy subjects. This would also benefit the close-knit multi-institutional team working on this issue. Finally, it is important to mention that this new type of robot is not without its challenges. At the same time, we call for a careful process of implementing telepresence and the establishment of new laws and guidelines to accompany the new era of telepresence robots. Telepresence robots have the potential to change the dynamics of healthcare in years to come. To ensure that these robots fulfill their potential, it is important to overcome challenges and to always keep in mind that these will have both beneficial and detrimental consequences. Full discourse is important to address challenging ethical issues. An ongoing healthcare dialogue is essential between academics, engineers, industry, and first-contact healthcare teams. The industry must not accept an attitude of 'we must design, but the end-user will have to get used to it' [24, 25].

CONCLUSION

Telepresence robots hold significant promise in enhancing healthcare accessibility and improving patient outcomes, particularly for individuals in remote or underserved areas. The integration of these technologies can reduce healthcare costs, improve patient engagement, and enable continuous monitoring, leading to better management of chronic conditions. However, some challenges need to be addressed, including technological limitations, ethical concerns regarding privacy and data security, and resistance from both healthcare professionals and patients. Moving forward, the development of more advanced robots, coupled with AI and other emerging technologies, could further improve their effectiveness. Ethical frameworks, adequate training, and careful integration into healthcare systems are essential for maximizing the potential of telepresence robots. Ongoing collaboration between technologists, healthcare professionals, and policymakers will be crucial to overcoming existing challenges and ensuring that telepresence robots fulfill their promise of transforming healthcare delivery.

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