Robotics in Healthcare

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Abstract

Robots are instilled in health care to raise patient care, current times. They are used in any setting from hospitals to rehabilitation centers and even walking assistance. The paper talks about the developments that are happening in robotic technology within the healthcare sector, more specifically the field of research in care, hospitals, assistive devices, rehabilitation, and walking assisting robots. It also touches upon patients' views concerning the combination of AI and robotic systems in health care, especially through their experiences of hospitalization during the COVID-19 period. Knowledge of these perspectives is capable of guiding in development of AI and robotic systems meeting citizens' needs, as well as contributing to the development of robots in healthcare.

Keywords— *Robots, Healthcare, Rehabilitation, AI (Artificial Intelligence), Patient care, COVID-19*

I. INTRODUCTION

The healthcare industry faces challenges such as staff shortages, social restrictions, and infection control measures. Despite the pandemic's subsided challenges, staff burnout, an elderly population, and backlog strains persist. Robotic systems can alleviate workforce pressures, including remote presence robots for virtual consultations and transportation robots for equipment delivery. They can also support clinical practice in specialties like exoskeletons and surgical robots. Understanding the role of researching and developing robots in the healthcare sector is essential for future advancements.

Accordingly, spiraling costs and the need to effect improvements in clinical, economic, and overall health outcomes are all challenges that face healthcare systems around the world. Progressively, this convergence of computing, sensing, networking, and communications technologies advances to automation, much more pronounced in the sphere of artificial intelligence (AI) and machine learning (ML). As automation and AI-based robotics start operating in healthcare, the realm of human-robot collaboration and AI convergence originates. Developments

in ML have shown that machines can be used to perform those tasks traditionally considered human capacities, such as abstract problem-solving, social interaction, perceptual recognition, and natural language use. It is believed that this New Robotics Age will carry out not only routine duties but will cooperate with a human on many types of activities. However, the problems of ethics and social integration appear anew by introducing AI systems and robotization in the healthcare setting. This paper brings an analysis of patient experiences of opinions, values, and concerns about AI and robotic systems as a function of their experience of care during the COVID-19 infection in Catalonia, Spain.

In 2050, this would be approximately 21.1% aged 60 years and above; it is a big chunk of the total world population. So, keeping sound physical and mental capability into old age, optimizing retirement age, and providing purpose and dignity to aged people have all become contemporary and burgeoning challenges of society. Yet, notwithstanding all odds, the case of health care workers and caregiving staff cannot be done away with altogether, since an acute shortage does loom large over hospitals, nursing and rehabilitation centers, and assisted living communities. Of all the most serious problems that nurses meet, the most acute is burnout, which aims at the reduction of the level of effectiveness of work and, of course, productivity. Robotics and AI have great potential and are one of the leading tools in future advancements to help and take care of human beings in various environments, including health care. This comprehensive survey paper presents a broad perspective on nonsurgical robots that support healthcare worker effectiveness, open challenges, and future research directions. The overview discusses different types of robots, including the hospital, care, assistive, rehabilitation, and walking assistants. The paper concludes with open challenges to robots in healthcare and the current technology readiness level.

II. METHADOLOGY

The methodology employed for this scoping review adhered to the principles and guidelines outlined in the Cochrane Handbook for Systematic Reviews of Interventions. The research explores the experiences of COVID-19 patients in Catalonia, Spain, through 13 semi-structured interviews. The interviews focus on the journey of illness, hospitalization, emotional landscape, and practical aspects of hospital life. The study uses an inductive method and semantic analysis to interpret the diverse responses from the interviewees. The findings extend knowledge of the human experience throughout the pandemic and specifically offer valuable insights into the experiences of direct victims. retirement age, and offering older individuals a purpose and dignity.

This study reviews the impact of the COVID-19 pandemic on the robotics industry, assessing its role in various sectors. It identifies emerging technologies, repurposed systems, and applications. The findings highlight the growth potential of the robotics industry, with increased acceptability and market demand beyond the pandemic. The review aligns with forecasts of substantial spending on robotics systems. The aging population is driving the shift from open-loop human-dominated systems to closed-loop Homecare Robotic Systems (HRS). This interdisciplinary field faces significant challenges but can be addressed using enabling technologies from Industry 4.0. Healthcare 4.0 refers to the adoption of CyberPhysical Systems (CPS) in healthcare, including intelligent sensing, automatic control, autonomous robotics, IoT, Big Data analytics, Fog and Cloud Computing, and Artificial Intelligence (AI).

The challenges of the aging society enable CPS to be applied in Homecare Robotic Systems with faster and more intelligent execution, providing effective in-home care. The objective of the present paper was to fish for the research papers on the robotic systems in healthcare through the digital libraries including IEEE Explore, ACM Digital Library, Science Direct, and Google Scholar. The initial list contained 105 robotic platforms, and it was further filtered on the basis of criteria such as not a surgical robot, having a physical prototype, and having an evaluation with a human subject. Finally, the 30 selected robotic platforms were compiled categorically, according to the application category. The COVID-19 pandemic accelerated research in hospital robotic platforms, adding eight to the final set. The search results on COVID-19 technology, robotics, AI, and digital technology revealed that there were 4,444 results. From the search, 163 candidates were found, and from this number, 88 were removed due to duplication. From the remaining 75, 50 candidates were manually analyzed and grouped in robotics, AI, and digital technology. These categories were further vetted based on role and categorized into sections for further selection.

This review focuses on the assessment of healthcare workers' needs for robotics in healthcare Amidst the COVID-19 pandemic, the search was carried out starting in August to September 2021, excluding abstracts, duplicate articles, blogs, news articles, promotional brochures, conference proceedings, and articles not related to robotics in healthcare. The review included 4,444 articles screened at title level by the first author, with four reviewers independently checking all the text for accuracy and suitability. Pandemic control robots have a range of applications for this technology, encompassing various uses; however, there are debates about the ethics of human-robot interaction, deployment, and the substitution of humans for robots. The utilization of antipandemic robots involves an intricate technical, social, psychological, and ethical issue. Few studies on China's attitudes toward robots exist, and this article centers around the Chinese public's perception and acceptance of these robots. The Chinese public's pretechnological tendencies may reflect this trend, as they have been exposed to multi-functional robots during the pandemic. Practicality is a key indicator of people's need for robot applications, and the general attitude towards anti-pandemic robots may be more pragmatic within the confines of the pandemic

III. LITERATURE REVIEW

Zang The most researched axis is certainly that which concerns the global increase of an aging population and correlated health problems. Scholars note the broad spectrum of challenges it poses: Sander et al. (year) articulate three main issues. One is biological, which deals with the possibility for one to maintain physical and mental ability in old age, hence making it a necessity. The second issue is social, dealing with optimizing the retirement age, whereas the other issue is cultural, which speaks to the offering of meaning and pride to old people. Of course, these problems underline the critical needs that healthcare providers and caregivers must be ready to face [1].

The growing prevalence of the issue of lack or deficit of caregivers across healthcare settings has become quite

common in the contemporary healthcare literature, especially in hospitals, nursing homes, and assisted living communities. This problem, although seemingly localized, has far-reaching effects that not only affect the elderly and their families but spread to all those who need care due to some affliction affecting the body or mind. There has also been another study through a questionnaire with 53,846 nurses from six different countries; it has been proved that nurse burnout is an alarming factor related to perceived care quality. Healthcare workers are followed by burnout symptoms such as the loss of energy, emotional exhaustion, and frustration, further affecting their health and productivity [2][3].

Health studies literature demonstrates a paradigm shift in healthcare with the integration of Robotics and Artificial Intelligence (AI). In fact, robots have, over time, become potential allies to human beings within the most varied contexts, not only at home but also within workplace settings and, even, schools. Regarding robots being used in settings that revolve around the provision of healthcare services, this has been quite some time now, given that records of the first time a robot was used in carrying out a surgical procedure go back to the year 1985. Over the last decade, there have been substantial technological advancements that have significantly improved the features of robot technology, hence making them primary assets in health care [4][5][6]

Increasingly, the literature is focusing on nonsurgical robots, designed for the support of healthcare workers such as nurses, caregivers, and therapists. These are hospital robots, care robots, assistive robots, rehabilitation robots, and walking assistance robots. The literature was written in order to highlight not only the overview of the currently existing situation but also to derive from this area the future challenges and possible directions of activity. Reviewing how effectively commercially available and research robots in each category are, in other words, what this review does, demonstrates the potential of robotic technology in healthcare [7].

Future research directions: The literature has proposed several questions that, if answered, would make an interesting area of future research and development work. What amount of work is there in the research conducted on healthcare robotics? How are the current generation of commercially available robots most likely to be used and what barriers to deployment are therefore most likely to be encountered as they move into real-world settings? Such issues will be useful for pointing out to researchers the current technology readiness levels of healthcare robots and, along with that, they can highlight the areas that may need further exploration [8]

. It is a structured survey paper with dedicated sections on types of care robots. Sections 2 through 6 of the paper describe care robots, recent developments at the hospital relating to robots, assistive robots, and rehabilitation and walking assist robots. Section 7 contains a further detailed discussion linking the open challenges presented in this paper and concluding with a more subtle conclusion than the paper itself [9]. Thus, this literature review goes beyond this paper's scope to capture the current discourse surrounding the elderly population and caregiver shortage, and more so, the transformative role that robotics is playing or set to play in the broad areas of healthcare challenges. The identified gaps and formulated research questions are the way forward toward future investigations, thus allowing the present field to be dynamic and evolving. The main critical and versatile roles that robotics plays amidst this pandemic are increased efficiency

in most industries and ensuring that critical social functionalities never come to a halt [4,5].

Putting huge weight behind many projects with robots and their possibilities, today the IEEE Foundation is armed against COVID-19 in developing countries and regions [6,7]. This paper joins the ongoing conversation by taking on a broad survey of robots and robotic systems that have either emerged during the pandemic or have been given new purpose. All these forms of robotics will be looked at in this review to get a better sense of how exactly they are helping us, therefore highlighting the uses of technology during a time of crisis. So, it is a way to tackle the short-term challenges but, at the same time, signals the power of technology and innovation to be at the forefront during a global health crisis. I thank the Editor and Associate Editor Hui Xie for shepherding this manuscript through the review and approval process.

Such a spirit of the academic community ensures valuable insight and knowledge is shared in a period of crisis. This paper reviews the challenges presented by COVID-19, our societal response, and how robotic technology is increasingly becoming a game-changer. This paper took the form of a focus on surveying emerging or repurposed robotic systems so as to provide readers with a taste of the large landscape of technological response developing during this long-standing global health crisis. The literature review conducted for this study involved searching electronic databases such as Google Scholar, PubMed, EBSCO, and Cochrane reviews for articles published from 2020 to 2021. The search was carried out using keywords such as "healthcare professional" OR "health worker" AND "COVID-19" AND "robot application" OR "robotics" OR "health technology" AND "needs assessment" OR "expectation" OR "perception". Inclusion criteria included full-text articles related to the assessment of healthcare workers' need for medical robotics during the COVID-19 pandemic, while exclusion criteria comprised abstracts, duplicate articles, blogs, news articles, promotional brochures, and conference proceedings.

A total of 13,692 articles were identified through the search engines, with PubMed yielding 179, Cochrane Library 1300, EBSCO 13, and Google Scholar 12,200. After screening, five full-text articles were found to fulfill the inclusion criteria. These articles were used to elucidate the demands and requirements of healthcare workers regarding medical robotics during the COVID-19 pandemic, categorizing robotic functions and identifying specific types of robots in demand, such as examination robots, disinfection and cleaning robots, and telemedicine robots. The literature review for the aforementioned abstract would typically delve into existing research and studies related to the utilization of robotics, artificial intelligence, and digital technologies in response to the COVID-19 pandemic.

Here's a summarized literature review: Robotics in Pandemic Response: Several studies have explored the role of robotics in various aspects of pandemic response, including disinfection of surfaces, delivery of medical supplies, and even patient care in isolation wards. Research highlights the effectiveness of robots in reducing the risk of transmission by minimizing human-to-human contact. Artificial Intelligence for Diagnosis and Monitoring: Literature on artificial intelligence (AI) applications in healthcare during the COVID-19 pandemic emphasizes its potential for rapid diagnosis through image analysis of chest X-rays and CT scans. AI algorithms can also analyze vast amounts of data to

track virus transmission patterns and predict outbreak hotspots. Digital Technologies for Contact Tracing and Remote Healthcare: Studies have examined the use of digital technologies such as mobile apps for contact tracing and monitoring symptoms remotely. These technologies enable timely identification of potential cases, thereby facilitating targeted interventions and reducing the spread of the virus. Challenges and Ethical Considerations: While technology offers promising solutions, the literature also discusses challenges such as privacy concerns, data security risks, and disparities in access to digital tools. Ethical considerations regarding the use of AI in healthcare decision-making and the impact of automation on job displacement are also explored. Future Directions and Recommendations: Scholars have proposed strategies for overcoming existing challenges and maximizing the potential of technology in pandemic response.

This includes investment in infrastructure for telehealth services, development of interoperable digital platforms, and establishment of regulatory frameworks to ensure ethical and equitable deployment of technology. Overall, the literature review provides insights into the diverse applications of robotics, artificial intelligence, and digital technologies in addressing various challenges posed by the COVID-19 pandemic, while also highlighting the need for careful consideration of ethical and societal implications. The literature review for the study on the perception and reception of anti-pandemic robots among the Chinese population during the COVID-19 pandemic would typically involve a review of existing research and scholarly articles related to several key areas.

Robots in Healthcare: This section will discuss previous studies on the use of robots in healthcare settings, including hospitals and quarantine facilities. It would cover topics such as the roles and functions of robots in medical care, their effectiveness in disease control, and their impact on healthcare professionals and patients. Public Perception of Robots: Here, the review will examine research exploring public attitudes and perceptions towards robots in various contexts, not limited to healthcare. This could include studies investigating factors influencing public acceptance of robots, such as familiarity, trust, perceived usefulness, and concerns about job displacement or ethical implications. Ethical Considerations: This section will delve into the ethical issues surrounding the use of robots in healthcare and pandemics. It would discuss debates around the potential for robots to replace human workers, concerns about privacy and data security, as well as broader ethical questions related to autonomy, accountability, and fairness. Cross-Cultural Perspectives: Given the focus on the Chinese population, the literature review should also include studies comparing attitudes towards robots across different cultures or countries.

This could highlight cultural factors shaping perceptions of technology and inform understanding of the findings within a broader societal context. Technology Adoption During Pandemics: This section will explore existing literature on the use of various technologies, including robots, during public health emergencies such as pandemics. It would discuss how technological innovations have been leveraged in previous outbreaks to aid disease surveillance, diagnosis, treatment, and prevention. By synthesizing findings from these areas, the literature review would provide a comprehensive background for the study, helping to contextualize its aims, hypotheses,

and significance within the broader research landscape on robots, healthcare, public perception, ethics, and pandemics.

IV. LIMITATIONS

The review of robotics in healthcare faces limitations due to personal biases in published literature, time constraints on insights, a mixed bag of study quality, a diverse range of robotic technologies, challenges in generalizing findings, lack of ethical and social oversight, evolving technological landscape, limited quantitative insights, and overlooking contextual factors. The review relies heavily on published studies, which may not capture the nuanced differences in implementation across diverse settings or demographic groups. The review may also not fully explore the ethical and social implications of integrating robotic systems in healthcare. The review's focus on qualitative analysis may limit its ability to provide quantitative insights. This study explores COVID-19 experiences in Catalonia, Spain through 13 semi-structured interviews. However, the sample size may limit generalizability, as the experiences may not fully capture the diversity of perspectives. The inductive method and semantic analysis may introduce subjectivity, and individual differences may influence the emotional and practical aspects of hospital life.

Despite these limitations, the research provides valuable qualitative insights and lays the groundwork for future studies. The study examines the impact of the COVID-19 pandemic on the robotics industry, highlighting emerging technologies and applications. However, it acknowledges the industry's growth potential but lacks a comprehensive understanding of challenges like ethical concerns and societal acceptance. The generalization of findings across sectors may oversimplify the nuanced impacts. Researchers and policymakers should consider these limitations and seek further investigation into the complex dynamics within the robotics industry This paper discusses the potential of Cyber-Physical Systems for Home Rehabilitation Services (CPSHRS) in enhancing in-home care services. However, it acknowledges limitations, such as the limited information from 150 references, the need for ongoing improvements, and uncertainty in practical implementation and scalability in diverse real-world scenarios.

The study emphasizes the need for critical thinking and ongoing contributions in this field. The paper discusses the potential of robotics and AI in healthcare to address aging populations and caregiver shortages. However, it acknowledges limitations such as the rapid advancement of technology, the focus on nonsurgical robots, potential hurdles like cost, infrastructure, and user acceptance, and the lack of ethical considerations like privacy and trust. The paper emphasizes the need for careful consideration of ethical, social, and practical implications in healthcare robotics implementation. The text highlights the limitations of various technologies, including navigation challenges in hospitals, security and privacy concerns, cost and safety concerns, accessibility and reach challenges, and adaptation of existing technologies. The use of AI-driven facial recognition and smartphone apps raises privacy and data security concerns, while larger self-driving vehicles are efficient but costly. The

scalability and applicability of existing technologies may also be limited.

The text emphasizes the need to address these limitations and ensure the timely availability of technologies. This review focuses on medical robots, excluding transporting medical materials, dispensing prescription drugs, hygiene, and clinical management. Future research should include other types and establish minimum standards for transregional legislation. Further research should focus on specific services and outcome measurement. The COVID-19 pandemic has prompted a shift in healthcare delivery systems, making medical robots a quality of care. The study's results may be influenced by sample bias, cultural specificity, time sensitivity, self-report bias, survey instrument validity, response rate, and language barriers. The Chinese population may not directly apply the findings to other contexts, and the survey's reliability and validity may impact the accuracy of measurements and interpretation. The response rate of 94.9% may indicate self-selection and nonresponse bias. Acknowledging these limitations is crucial for a comprehensive and balanced interpretation of the findings.

V. CONCLUSION

In this respect, the research delves deeper into how the COVID-19 pandemic affects public health authorities and hospitals in China. It takes into account 50 technologies under robotics, AI, and digital technology currently applied in hygiene management, patrol, screening, diagnostics, health advice, and virus tracking. The limitations of these findings include bias in the sample, cultural specificity, time sensitivity, self-report bias, survey instrument validity, response rate, as well as language and translation. The study emphasizes the challenges that have to be dealt with by public health authorities and hospitals, namely maintaining social distancing, reducing personal contact, ensuring quick diagnosis, tracking the spread of the virus, and providing sanitation facilities. It also considers security and privacy issues in implementing these technologies. It serves as an opportunity to learn from the pandemic in preparing for future emergencies by establishing protocols for adapting existing technologies more readily and at scale. The study emphasizes the importance of considering the primary users of medical robots during the pandemic.

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