








## NARRATIVE REVIEW

# Virtual reality applications for rehabilitation of COVID-19 patients: A systematic review

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## Abstract

**Background and Aims:** The COVID-19 pandemic has changed people's lifestyles as well as the way healthcare services are delivered. Undoubtedly, the difficulties associated with COVID-19 infection and rehabilitation and those associated with quarantine and viral preventive efforts may exacerbate the need for virtual reality to be used as a part of a complete rehabilitation strategy for these individuals. Thus, the present research aimed to evaluate the potential uses of virtual reality for the rehabilitation of individuals suffering from COVID-19.

**Methods:** From 2019 to March 1, 2022, a systematic search was conducted in PubMed, Cochran Library, Scopus, Science Direct, ProQuest, and Web of Science databases. The papers were selected based on search terms and those that discussed the use of virtual reality in the rehabilitation of COVID-19 patients were reviewed. Each step of the study was reviewed by two authors.

**Results:** A total of 699 papers were found during the first search. Three papers were chosen for further investigation after a thorough evaluation of the publications' titles, abstracts, and full texts. Cross-sectional studies, randomized controlled clinical trials, and case reports comprised 33%, 33%, and 33% of the publications, respectively. Based on the results, people suffering from COVID-19 were the focus of two papers (66%) that employed immersion virtual reality for cognitive rehabilitation, whereas one study (33%) used non-immersive virtual reality for physical rehabilitation. In two papers (66%), virtual reality was also offered to patients in the form of a game.

**Conclusion:** According to the results of the present research, virtual reality games may enhance functional and cognitive consequences, contentment levels among patients, and their ability to take charge of their own health care. In light of the obstacles faced by COVID-19 patients, alterations in the delivery of healthcare, and the significance of rehabilitation in this group during quarantine, new techniques

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have been considered for these patients to maintain treatment, return to regular life, and enhance their standard of life.

#### KEYWORDS

COVID-19, health, rehabilitation, virtual reality

## 1 | INTRODUCTION

Wuhan, China was the site of the initial discovery of the novel SARS-CoV-2 coronavirus in December 2019. After that, the virus swiftly propagated around the globe. In March 2020, the World Health Organization (WHO) announced the emergence of a pandemic. As a result of COVID-19, patients might suffer from such symptoms as weakness, lethargy, Posttraumatic Stress Disorder, post-care syndrome, dementia, physical and occupational disabilities, dysphagia, malnutrition, myalgia, arthralgia, acute respiratory distress syndrome, multiple organ failure, post-activity shortness of breath, atrophic muscles, and premature death. Patients' quality of life is negatively affected by these conditions during and after their hospitalization, making the recovery more complicated and time-consuming. There have been several national difficulties arising as a result of the lengthening of the sickness and its recovery period on the one hand, and quarantine, shutdown of private and public places, travel limitation for overseas nationals, and other measures taken to restrict the dissemination of the virus on the other hand. These have significantly influenced the emotional, psychological, physical, and monetary well-being of individuals of all ages and have increased the urgency of rehabilitation treatments. In fact, the COVID-19 pandemic has led to an economic crisis and a health emergency whose adverse effects are not equally distributed across sectors, regions, communities, and countries.<sup>1-7</sup>

As defined by the WHO, rehabilitation refers to a combination of activities meant to improve individuals' performance and decrease their impairment.<sup>8</sup> Individuals experiencing COVID-19 need a combination of cognitive (like mindfulness and meditation techniques) and physical (like exercise therapy) rehabilitation, which can put public and private care systems under a burden and result in a lengthy hospitalization and a lack of sufficient access to healthcare.<sup>1-3</sup> Generally, rehabilitation is a difficult, unpredictable, lengthy, and tiresome domain that may limit patients' commitment to therapy, decline rehabilitation results, and alleviate quality enhancement.<sup>9</sup> Therefore, a worldwide reaction and readiness against COVID-19 are critical. Considering the short- and long-term consequences of the virus,<sup>10</sup> it is preferable to develop rehabilitation measures that assist patients in alleviating their manifestations and adapting to their new environment as well as the therapy.<sup>1</sup> In this context, many medical professionals have been obligated to employ virtual procedures and digital technologies instead of conventional ones because of the current situation. In fact, disease outbreaks and pandemics have changed people's behaviors, transformed societies, affected personal relationships, and changed global paradigms.<sup>5,10</sup> Telerehabilitation, active video games, augmented reality (AR), and

virtual reality may all be regarded as potential strategies for preventing or responding to pandemics in this respect.<sup>10-12</sup>

Telerehabilitation is an alternative method of providing everyday rehabilitation treatments to patients using information and communication technology. It allows patients to receive treatment at any time and any place.<sup>12</sup> The games that demand interactive physical activity in addition to passive control using typical manual controllers are classified as active video games.<sup>11</sup> Rather than providing entertainment, their mission is to assist recovery. Although these games may offer motivating, challenging, rewarding, and entertaining experiences while helping to improve learning, they are not specifically developed for rehabilitation applications in the traditional sense. Because these games need less computing time for 3D modeling, they are more inexpensive compared to virtual reality. Due to the lack of customization and models of rehabilitation hypothesis throughout the creation process, their distribution has been restricted.<sup>12</sup> In AR, real and virtual worlds are combined to allow the user to communicate with computer-generated information that has been added to the real world.<sup>10</sup> On the contrary to virtual reality settings, enhanced reality settings are not computerized and they are thus more inexpensive than virtual reality environments.<sup>12</sup> Using a computer to simulate the actual situation, virtual reality allows users to communicate with an artificial environment that looks and feels remarkably like reality. A wide range of applications is possible with this technology including therapy, surgery, education, pain management, and rehabilitation in the healthcare system.<sup>13-18</sup> Earlier investigations have underlined the necessity to employ various ways of delivering rehabilitation at home.<sup>19,20</sup> By giving feedback, extending the duration of workouts, enhancing the number of iterations, customizing activities, engagement, patients' pleasure and motivation, performance evaluation, decreasing discomfort, and increasing performance, virtual reality assists patients in doing exercise at home.<sup>9</sup> Additionally, virtual reality increases exercise participation by establishing sensory-motor contacts between the user and the virtual world, adapting to therapy, modifying the complexity level of workouts, following treatment, enhancing concentration and enthusiasm, assuring patient security, and managing patients. This contributes to the improvement of patients' functioning.<sup>12</sup>

### 1.1 | Literature review

Several studies have been conducted on the design and development of virtual reality in rehabilitation. In research performed by Triandafilou et al. on the establishment of a 3D virtual reality setting and multi-user network for home treatment following a stroke, more than 85% of the participants believed that virtual reality was an

efficient way of encouraging repeated arm workouts and expressed a strong willingness to carry out the exercises.<sup>21</sup> To provide upper extremity activities for stroke patients, Qiu et al. created a virtual rehabilitation system that could be used at home. Patients who were able to use the system correctly with little help had much better function in their upper limbs.<sup>22</sup> The Choi et al.'s study was conducted for the rehabilitation of the upper limbs of cerebral palsy children aged 3–16 years. The intervention group ( $n = 40$ ) received virtual reality rehabilitation programs with RAPAEL Smart Kids (i.e., virtual reality games to strengthen the wrist and forearm joint movements using wearable sensors) and traditional occupational therapy programs, while the control group ( $n = 40$ ) received only traditional occupational therapy (i.e., stretching, strength, and task-oriented exercises). The upper limb function of both groups improved after treatment, but more improvement was achieved in the intervention group. Therefore, the virtual reality rehabilitation system was effective for motor training.<sup>23</sup> Another study was conducted by Joo et al. for the rehabilitation of 57 hand burn patients (54 men and 3 women) in Korea. The traditional rehabilitation group received 60 min of standard treatment that included exercise rehabilitation, while the virtual reality group received 30 min of standard treatment and 30 min of rehabilitation based on virtual reality games using RAPAEL Smart Glove. The interventions were carried out for 4 weeks. Performance of both groups improved, but the virtual reality group showed greater satisfaction with the treatment. Therefore, virtual reality can be considered as a treatment option for hand burn patients.<sup>24</sup>

Pazzaglia et al. studied the rehabilitation of 51 Parkinson's patients. Patients were divided into two groups: virtual reality and traditional rehabilitation, and they received treatments for 6 weeks (40 min each session, 3 times a week). Traditional rehabilitation included warming up, coordination exercises of upper and lower limbs, balance exercises, strengthening respiratory muscles, walking, and so forth. Virtual reality rehabilitation included the use of the NIRVANA system for upper and lower limb coordination exercises as well as trunk control. The results showed that virtual reality rehabilitation has better outcomes for various functions compared to traditional rehabilitation.<sup>25</sup>

However, no review article has been done on the uses of virtual reality for the rehabilitation of COVID-19 individuals. Nonetheless, earlier review articles have discussed the employment of virtual reality for the rehabilitation of individuals with different disorders throughout the COVID-19 pandemic.<sup>16,26,27</sup> Thus, virtual reality applications for the rehabilitation of COVID-19 patients must be reviewed in light of the present scenario. In fact, research needs to be performed on the usefulness of virtual reality in rehabilitating individuals suffering from COVID-19, the most prevalent type of virtual reality (immersed, semi-immersed, and no-immersed), and the most frequent virtual reality products (video games or video clips). Research on the use of virtual reality for the rehabilitation of COVID-19 individuals can emphasize their importance for the design and development of subsequent investigations into the employment of virtual reality for the rehabilitation of aged and handicapped people and inhabitants of distant locations. According to the investigations, no study was found that was conducted in a review to examine the applications of virtual reality for the rehabilitation of patients suffering from COVID-19 so that it

could be used for future pandemics. Therefore, the present study aims to evaluate the potential uses of virtual reality in the rehabilitation of individuals suffering from COVID-19.

## 2 | METHODS

### 2.1 | Eligibility criteria and search strategies

#### 2.1.1 | Search strategy

The study protocol was registered in the PROSPERO<sup>1</sup> database under the identification number CRD42022314863. The search strategy for this study was a PRISMA<sup>2</sup>-compliant systematic review. The study topic; that is, “what are the uses of virtual reality for the rehabilitation of individuals with COVID-19,” was searched in peer-reviewed and English-language publications from 2019 to March 1, 2022. The Cochrane Library database was also searched to guarantee that no identical systematic reviews were published. The results revealed no similar papers. PubMed, Cochran Library, Scopus, Science Direct, ProQuest, and Web of Science were some of the searched databases. Gray literature, such as books, websites, and conference articles, were searched, as well. Using the “AND” operator allowed the researchers to compare sets of words that were treated as distinct concepts. Additionally, the “OR” operator was employed between synonymous words. The titles, abstracts, and keywords of the articles were searched. Mesh terms were utilized in the PubMed database to search for papers. The search strategy has been presented in Table 1. C or the identical comparison group was not included in PICO since there was no comparison group in this study.

The terms for the search were selected by the researcher. Then, the factors were retrieved from the papers chosen for analysis. Subsequently, a comprehensive list of all the publications' references was compiled, after which the titles of the papers were reviewed. The papers that were found to be irrelevant to the study goals were excluded. As a precautionary measure, all search processes were carried out twice. The management of the resources was carried out using END NOTE version X9 software.

### 2.2 | Inclusion criteria

The papers with virtual reality rehabilitation applications in the title, keywords, or abstract were chosen initially. Next, the abstracts were assessed and full texts were evaluated using assessment techniques. The extracted papers from 2019 to March 1, 2022 included systematic reviews. Unreleased studies (gray literature), procedures, conference articles, guidelines, instructions, and reports from respected institutions were also reviewed. Quantitative and qualitative criteria were used to choose the best papers for inclusion in the reviews. Search terms might be found in the documents' titles, abstracts, or keywords. The papers had to be directly relevant to the study subject. Peer-reviewed articles were also included in the selection process.

PIO	#1 AND #2 AND #3	Strategy
P	COVID-19 OR COVID19 OR Severe acute respiratory syndrome coronavirus 2 OR Coronavirus OR SARS-Cov-2 OR New coronavirus OR Corona	#1
I	VR OR Virtual Reality OR Virtual simulation OR Virtual environment OR Virtual Reality simulator OR Virtual Reality Exposure Therapy OR Virtual Reality immersion therapy	#2
O	Rehabilitation OR rehab OR recovery OR reconstruction OR physical therapy OR physiotherapy OR exercise therapy OR physical activity	#3

**TABLE 1** Search strategy for the application of virtual reality for COVID-19 individuals' rehabilitation

### 2.3 | Exclusion criteria

The articles that included irrelevant parameters to the study objective were excluded.

### 2.4 | Screening

Initially, the titles of all the papers in the database were verified to ensure that they were relevant. Articles were chosen in case they met the inclusion criteria and were relevant to the study objective. Subsequently, the abstracts of the chosen papers were reviewed. In the next step, the papers that were totally in accordance with the study goal and the inclusion criteria were chosen, and their full texts were reviewed and assessed by the author. Ultimately, the publications discussing the use of virtual reality in the rehabilitation of COVID-19 individuals were selected. The papers were assessed according to the PRISMA guidelines. Citation and print bias were also considered, and the papers featuring high citations were meticulously assessed. All the abovementioned stages were repeated twice.

### 2.5 | Data collection

Based on the summary and collection forms created using Microsoft Word 2016 software, the necessary data were retrieved from the articles after they were carefully read and discussed. This form included parts for the title, corresponding author, research aims, study population, study sample, country, year, study design, tools, methods, results, and conclusion. The summary forms were completed for each of the selected papers. Once the two authors finished evaluating all the papers, all the forms were evaluated and shown in a table. In case of disagreements, other authors were asked to give their opinions.

### 2.6 | Ethical consideration

The informed consent form is not applicable in this study. Ethical considerations, including logical and scientific analysis of the articles, were also done without any bias.

## 3 | RESULTS

After extensive searching, 699 papers were extracted from the databases. Nevertheless, 68 papers were excluded due to their duplication in many databases. Additionally, 436 articles were excluded because their titles were irrelevant to the study objective. Following a thorough evaluation of the remaining 195 abstracts from the previous stage, 147 papers were deemed unsuitable for inclusion in the investigation. In the end, 10 full-text articles were selected for the research. Among these 10 publications, only 3 met the research objectives. The paper selection process has been shown in a flow diagram in Figure 1.

An overview of the types of the extracted papers has been presented in Table 2. Accordingly, one paper was a cross-sectional study (33%), one paper was a Randomized Controlled Trial (RCT; 33%), and one paper was a case report (33%).

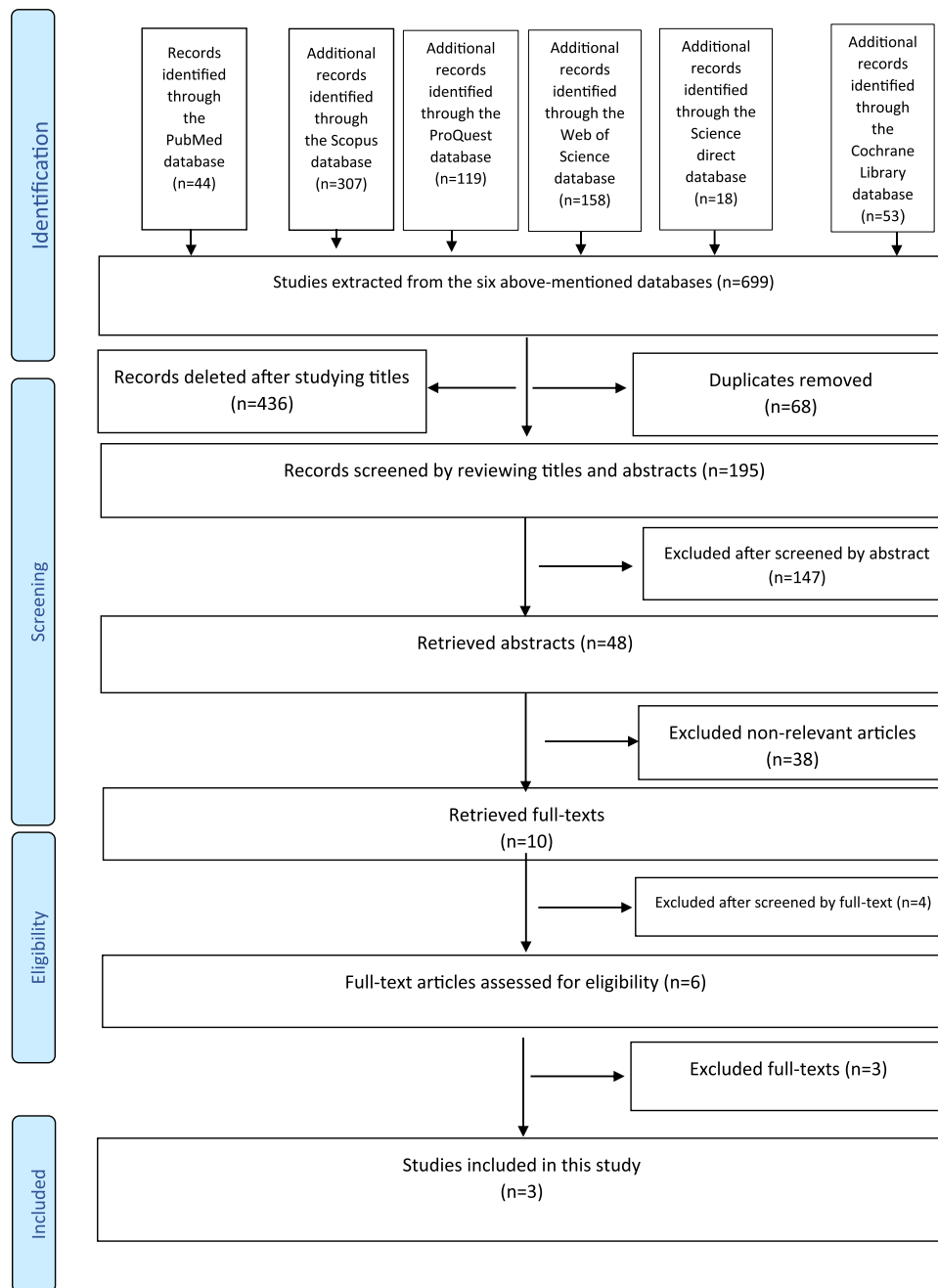
The uses of virtual reality in the rehabilitation setting and the most often employed types of virtual reality (immersed, semi-immersed, and non-immersed) and virtual reality products (games and video clips) amongst COVID-19 patients have been highlighted in Table 3. Based on the results, people suffering from COVID-19 were the focus of two papers (66%) that employed immersion virtual reality for cognitive rehabilitation, whereas one study (33%) used non-immersive virtual reality for physical rehabilitation. Virtual reality was also offered to patients in form of a game in two papers (66%).

The three papers' full texts have been summarized in Table 4. The data include titles, corresponding authors, research aims, study populations, study samples, countries, years, study designs, tools, methods, results, and conclusions.

## 4 | DISCUSSION

Using virtual reality for the rehabilitation of COVID-19 patients has increased functional and cognitive results and has led to a higher level of contentment.<sup>1-3</sup> Recently, virtual reality has been used more commonly by doctors and investigators as an improved instrument for rehabilitation in response to healthcare expenses and patient contact.<sup>28-31</sup> More time and additional research are required to determine how this technology may be used during the pandemic.

In addition to organ malfunction, COVID-19 has been characterized by neurological impairments, apnea, undernourishment, and



**FIGURE 1** PRISMA flow diagram for the paper screening approach

**TABLE 2** Types of the selected papers

Study	Percentage (%)	Number	References
Cross-sectional	33	1	[1]
Randomized controlled clinical trial	33	1	[2]
Case report	33	1	[3]

frailty, all of which contribute to a high mortality rate. The majority of patients report no manifestations at all, while just 15% report symptoms that may be considered moderate. Fever, cough, weariness, apnea, and myalgia have been mentioned as the most prevalent

manifestations, and patients may be hospitalized for several days in more severe situations.<sup>1-3</sup> COVID-19 patients have a variety of rehabilitation obstacles, which necessitates the deployment of suitable techniques to meet these problems. Rehabilitation treatments provided at traditional medical centers have been found to be useful according to the published evidence. However, in many low- and middle-income countries with inadequate resources, rehabilitation services for severely sick COVID-19 patients are hampered by logistical obstacles, economic constraints, lack of personnel and hospital equipment, epidemic conditions, and quarantine. Thus, it may be possible to avoid the spread of the virus by using virtual techniques and new online digital solutions that provide patients with simple and ongoing access to care services instead of conventional

**TABLE 3** An overview of the applications as well as the most often observed types and products of virtual reality for the rehabilitation of individuals with COVID-19

Virtual reality applications	References	Percentage (%)
Cognitive rehabilitation	[1,3]	66
Physical rehabilitation	[2]	33
<b>Type of virtual reality</b>		
Immersed	[1,3]	66
Non-immersed	[2]	33
<b>Virtual reality products</b>		
Game	[1,2]	66

rehabilitation procedures. It is also essential for the initial diagnosis and care of those infected with the virus.<sup>32–36</sup> The COVID-19 pandemic has changed knowledge, attitudes, and practices towards the use of virtual approaches and digital solutions. Apart from entertainment, their use in disasters has been effective as a simple method of communication due to their accessibility and ease of use. These solutions provide access to real-time information about global events and social interactions with others and meet social information needs.<sup>36,37</sup> Regarding the pandemic circumstances, virtual reality is a viable alternative.<sup>10</sup> As a result of COVID-19, the significance of virtual reality in the rehabilitation sector has been brought to light. In other words, prompt presence and relief operations are critical for a successful catastrophe response. Thus, the implementation of novel disaster rehabilitation procedures has improved the efficiency of treatment.<sup>38,39</sup>

The vast majority of investigations were undertaken in developed nations such as the United States and the Netherlands.<sup>1,3</sup> Some of the primary motivations for paying attention to virtual reality in developed nations where the availability of many forms of technology, a powerful IT infrastructure, a high level of computer literacy among patients, governmental regulations, and policymakers' interest in the deployment of virtual rehabilitation approaches.<sup>32,40</sup> The current research findings revealed that while developed nations have dominated the virtual reality tools industry in recent years, developing countries including Brazil have become more reliant on this technology. In fact, virtual reality has progressed from a luxury and costly technology to a more pragmatic technology that may be employed in the realm of healthcare.<sup>13</sup> A cross-sectional research was done in the United States to assess the possibility of delivering virtual reality games for cognitive rehabilitation of hospitalized individuals due to COVID-19. The participants used the SootheVR headset while watching the game and reported having a pleasant impression.<sup>1</sup> In a case report, an individual with COVID-19 underwent cognitive rehabilitation following discharge from hospital in the Netherlands. The ICU-VR software and the virtual reality headset were shown to minimize the emotional effects of hospitalization in that research. Additionally, the patients' anxiety and depression began to subside.<sup>3</sup> In another clinical trial carried out in Brazil, the MoveHero game and wearable sensors were used to give physical

rehabilitation (i.e., exercise therapy) to hospitalized COVID-19 patients. The study findings indicated an improvement in functional and physiological characteristics.<sup>2</sup>

Regarding the cognitive rehabilitation of COVID-19 patients, virtual reality was employed in 66% of the investigations.<sup>1,3</sup> In general, neurological impairment commonly causes cognitive dysfunction, which significantly affects social interactions, independence, and employment chances. This eventually results in a decrease in the quality of life.<sup>12</sup> Enhancing sensory feedback in virtual reality improves cognitive areas including attention, operational memory, problem-solving, and data processing speed.<sup>41</sup> Up to now, several investigations into the use of virtual reality for cognitive rehabilitation have progressed beyond the scope of COVID-19. For instance, Maggio et al. proved the efficacy of a semi-immersed virtual reality therapeutic system for cognitive and behavioral rehabilitation of patients with Parkinson's disease. The results also demonstrated that traditional approaches were not as successful as virtual reality.<sup>42</sup> Similarly, Park et al. performed research to evaluate the usefulness of virtual reality among seniors experiencing mild cognitive impairment. Based on the results, virtual reality had a stronger influence on rehabilitation desire and cognitive function compared to conventional rehabilitation (e.g., puzzles, playing cards, etc.).<sup>43</sup>

A large number of interventions were carried out in hospital settings. As a matter of fact, conducting exercises in a hospital setting enables patients to complete the exercises in the presence of the individual delivering the intervention, and the outcomes of the workouts can be documented. In addition, patients have the opportunity to receive counseling, if necessary.<sup>1,2</sup>

Investigations using immersive virtual reality to treat patients were employed in 66% of the studies.<sup>1,3</sup> Due to the increased involvement of patients, the type of immersion appears to be extremely important in rehabilitation.<sup>16</sup> A three-dimensional virtual setting is used in the immersion type. As a result, the user is completely immersed in the virtual world and is completely unconscious of the real world around. In this form of intervention, virtual reality headsets are often employed. When using a virtual reality headset, the user feels more present and immersed in the virtual environment.<sup>28</sup> These findings were aligned with those of a prior research that employed immersive virtual reality for rehabilitation. This technique was utilized by Huang et al. to enhance upper extremity motor function among stroke patients.<sup>44</sup> Immersed virtual reality was also used by Rutkowski et al. for pulmonary rehabilitation.<sup>45</sup> The current study findings also indicated that virtual reality in form of games was employed for rehabilitation objectives in 66% of the papers.<sup>1,2</sup> According to the findings, patients' engagement, experience, and enthusiasm were increased when the games had interactive characters and provided feedbacks.<sup>12</sup> Yet, virtual reality-based rehabilitation studies need to have access to virtual reality products. Therefore, this problem should be taken into consideration in future studies.

Therefore, it is recommended to further explore Artificial Intelligence (AI) and AR functionalities in pandemics and healthcare, including conducting clinical trial studies to investigate the

TABLE 4 A summary form of the ultimately selected papers

Nos.	Corresponding author/title/reference	Aim	Population	Sample	Country	Year	Design	Tools	Methodology	Results	Conclusion
1	Laura Kolbe et al. Use of virtual reality in the inpatient rehabilitation of COVID-19 patients. <sup>1</sup>	The purpose of this descriptive research was to determine the possibility of offering virtual reality games to COVID-19 patients and personnel in New York City and to determine patient contentment and expected advantages of virtual reality.	COVID-19 individuals and recovery personnel at New York City University Hospital	13 COVID-19 individuals and 11 recovery personnel at New York City University Hospital	United States	2021	Descriptive, cross-sectional, qualitative	Software: applied VR game. Hardware: SootheVR headset, PPE equipment and banner. Assessment scales: A 4-item questionnaire assessing contentment and expected advantages of virtual reality.	This cross-sectional research was conducted on 13 patients and 11 personnel in a COVID-19 rehabilitation unit at the New York University Hospital using virtual reality games in three groups including directed meditation, discovering natural landscapes, and cognitive-stimulation games. The sessions were limited to 30 min in length. Virtual reality games and headsets were also used to deliver cognitive rehabilitation services to hospitalized patients and recovery personnel. After their initial encounter with the games, the respondents were assessed.	A pleasant 3D environment based on immersive virtual reality activities (- e.g., swimming with dolphins, singing with a bowl, etc.) was created in this study for cognitive rehabilitation of COVID-19 individuals and health care workers at the University Hospital in New York. The participants had a favorable impression of virtual reality treatment. The results revealed that the median patient contentment was 9 and the mean contentment rate was 8.42 (on a scale from 1 to 10). However, the median contentment for health care workers was 10 and the mean contentment was 9.45 (on a scale of	The findings of this study demonstrated the viability of providing virtual reality rehabilitation therapy during the COVID-19 period and the participants' happiness with this treatment approach. This study showed that virtual reality might be used as a complete rehabilitation model to help patients cope with anxiety and loneliness during the pandemic. It could be beneficial to patients in this situation. As a result, additional research in the area of rehabilitation is required to better comprehend the advantages of virtual reality over conventional therapy.

(Continues)

TABLE 4 (Continued)

Nos.	Corresponding author/title/reference	Aim	Population	Sample	Country	Year	Design	Tools	Methodology	Results	Conclusion
										1 to 10). This demonstrated their increased interest in and contentment with virtual reality treatment. Virtual reality, according to all participants, improved their therapy and well-being. They also suggested it to others. The survey findings revealed increased users' engagement, immersion, enthusiasm, feeling of dealing with COVID-19, and self-care via this technology.	
2	Talita Dias da Silva et al. Comparison between conventional and non-immersive virtual reality in the rehabilitation of individuals in an inpatient unit for the	This protocol research aimed to evaluate non-immersion virtual reality therapy with standard physiotherapy approaches following hospitalization caused by COVID-19.	Patients admitted to the COVID-19 ward	50 hospitalized patients with COVID-19	Brazil	2021	Randomized crossover trial	Software: G * Power 3.1.5, SPSS 26.0, MoveHero software, and the Internet. Hardware: Computers and wearable sensors. Assessment scales:	During this study, 50 individuals aged 18-90 years who were hospitalized to undergo physiotherapy (physical rehabilitation) for an initial diagnosis of COVID-19 were treated with two types of non-immersion virtual reality games (exercise	Considering the importance of benefits from physical activity during hospitalization, VR software shows promise as a potential mechanism for improving physical activity. The results of this study may provide new	Virtual reality may bring fresh perspectives on how to utilize this technology to enhance the functionality and engagement of COVID-19 individuals while they are in the hospital. Consequently, the findings of this study provide solid scientific evidence for the employment of



TABLE 4 (Continued)

Nos.	Corresponding author/title/reference	Aim	Population	Sample	Country	Year	Design	Tools	Methodology	Results	Conclusion
	treatment of COVID-19: A study protocol for a randomized controlled crossover trial. <sup>2</sup>							HRV (Heart Rate Variability), Barthel Index, TUG (Timed Up and Go), MRC (Medical Research Council), BRUMS (Brunel Mood Scale), ES (Enjoyment Scale), VASS (Visual Analogical Satisfaction Scale), Borg Scale, SaO2 (Oxygen saturation), RR (Respiratory rate), and HR (Heart rate).	therapy using non-immersion virtual reality games on the web platform) and conventional intervention (traditional musculoskeletal and cardiovascular physiotherapy). They were randomly split into two groups: group A (25 patients who received 10 min of virtual reality intervention in the morning and 10 min of conventional treatment in the evening) and group B (25 patients who received 10 min of conventional treatment in the morning and 10 min of virtual reality intervention in the evening). They were engaged in a crossover project for 2–8 days. All participants were examined twice (once at the beginning	insights into hospital rehabilitation. According to the findings of this study, both virtual reality therapies and conventional therapy increased motor, functional, and physiological indicators. However, virtual reality intervention was more appealing to patients because it increased patient involvement by offering feedback on the truthfulness or inappropriateness of workouts, running the game in a standing or sitting situation relying on the patient's potential, showing avatars at the bottom of the computer monitor, presenting music during the game, presenting marks from games, displaying the moment left until	virtual reality during rehabilitation.

(Continues)

TABLE 4 (Continued)

Nos.	Corresponding author/title/reference	Aim	Population	Sample	Country	Year	Design	Tools	Methodology	Results	Conclusion
3	Michel E. van Genderen et al. Intensive care unit-specific virtual reality for psychological recovery after ICU treatment for COVID-19; A brief case report <sup>3</sup>	The purpose of this study was to develop a virtual reality-based intensive care center for the post-discharge cognitive rehabilitation of COVID-19 patients.	Patients with COVID-19	A 57-year-old man with COVID-19	Netherland	2021	Case-report	Software: intensive care unit-specific virtual reality (ICU-VR) software. Hardware: Virtual reality headset. Assessment scales: the hospital anxiety and depression scale (HADS) and impact of event scale-revised (IES-R)	In this study, six intensive care unit simulation sessions based on immersed virtual reality (video clip) were developed for cognitive rehabilitation of COVID-19 patients following discharge. Before the intervention, 7 days after the intervention, and 6 months after the intervention, anxiety, and depression were assessed in the hospital setting.	According to the findings of this study, simulation based on immersed virtual reality in the ICU gave a positive experience in decreasing the psychological effects of patients following discharge from the ICU and was relatively useful in cognitive rehabilitation of individuals. Overall, the results indicated that using virtual reality as an energetic therapeutic strategy for individuals admitted to the COVID-19 unit would result in patients' better comprehension of the ICU atmosphere.	This study found that virtual reality treatments could mitigate the psychological effects of COVID-19, hence improving cognitive rehabilitation and living standards. In the present circumstances, virtual reality treatments are suggested to be used on a larger sample size.

effectiveness of this technology in the diagnosis and treatment of diseases; health policy makers accepting and implementing these products; designing user-centered content of AI applications; evaluating the readiness and acceptance of this technology in different countries; developing cost-effective AI and AR products; providing sufficient infrastructure; improving computer literacy and educating the use of AI; and developing evidence-based educational content for AI.

To the best of our knowledge, this was the initial investigation on the use of virtual reality for the rehabilitation of individuals suffering from COVID-19.

#### 4.1 | Limitations

The major drawbacks with the research were not being able to use the Embase database and only using papers written in English.

#### 4.2 | Implications and suggestions for future study

To better understand how virtual reality may be used to help COVID-19 patients, the following suggestions and recommendations are assumed: Pulmonology as COVID-19-related, execution of virtual reality products by health policymakers, user-based virtual reality content creation, assessment of the adoption of this innovation in various groups, emphasis on clinical trials to evaluate the efficacy of virtual reality and conventional rehabilitation treatments, production of cost-effective virtual reality materials, usage of inexpensive and available equipment, supply of suitable infrastructure, development of patients' and therapists' technical capabilities, redesign of virtual reality instruments, and development of content for virtual environments in compliance with guidelines and empirical data.

### 5 | CONCLUSION

In light of the obstacles faced by COVID-19 patients, alterations in the delivery of healthcare, and the significance of rehabilitation in this group during quarantine, new techniques have been considered for these patients to maintain treatment, return to regular life, and enhance their standard of life. According to the results of the present research, virtual reality games may enhance functional and cognitive consequences, contentment levels among patients, and their ability to take charge of their own health care. In this method, the user is immersed in an environment filled with visual and audio stimulation. Thus, virtual reality may be employed during rehabilitation. Nonetheless, further thorough studies are required to fully understand and uncover the potential benefits of this technology for patient rehabilitation.

#### AUTHOR CONTRIBUTIONS

**Conceptualization:** Milad Ahmadi Marzaleh and Fatemeh Sarpourian.

**Formal Analysis:** All authors. **Funding Acquisition:** Nill. **Writing – review and editing:** All authors. **Writing – original draft:** All authors.

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#### CONFLICT OF INTEREST

The authors declare no conflict of interest.

#### TRANSPARENCY STATEMENT

The lead author Fatemeh Sarpourian affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

#### DATA AVAILABILITY STATEMENT

Data are openly available in a public repository that issues data sets with DOIs.

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#### ENDNOTES

<sup>1</sup> International Prospective Register of Systematic Reviews.

<sup>2</sup> Preferred Reporting Item for Systematic Reviews and Meta-analyses.

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