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REVIEW

Post-stroke rehabilitation in the peri-pandemic COVID-19 era

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Abstract

The coronavirus disease 2019 (COVID-19), which arose in late 2019, caused extensive destruction, impacting a substantial proportion of the worldwide population and leading to millions of deaths. Although COVID-19 is mainly linked to respiratory and pulmonary complications, it has the potential to affect neurologic structures as well. Neurological involvement may manifest as minimal and reversible; however, a notable proportion of cases have exhibited pronounced neurological consequences, such as strokes. Endothelial inflammation, hypercoagulation, renin–angiotensin–aldosterone system alterations, and cardiogenic embolism are the pathophysiological mechanisms of stroke under COVID-19 circumstances. Physical activity and exercise have improved several aspects of post-stroke recovery, including cardiovascular health, walking capacity, and upper limb strength. They are commonly used to assist stroke survivors in overcoming their motor restrictions. Furthermore, stroke rehabilitation can incorporate a range of specific techniques, including body-weight-supported treadmill applications, constraint-induced movement therapy, robotic rehabilitation interventions, transcranial direct current stimulation, transcranial magnetic stimulation, and prism adaptation training. Under pandemic conditions, there were several barriers to neurological rehabilitation. The most significant of these were individual's fear of infection, which caused them to postpone their rehabilitation applications and rehabilitation areas being converted into COVID-19 units. The primary emphasis had turned to COVID-19 treatment. Several valuable data and views were gained in reorganizing rehabilitation during the pandemic, contributing to establishing future views in this regard.

Keywords COVID-19 · SARS-CoV-2 infection · Stroke · Rehabilitation · Neurological rehabilitation · Telerehabilitation · Rheumatic diseases

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Introduction

The worldwide influence of the coronavirus disease 2019 (COVID-19) was profound, affecting a substantial portion of the worldwide population and resulting in millions of losses [1, 2]. While COVID-19 is primarily linked to respiratory and lung-related issues, it can also have varying degrees of effect on different regions of the human body, encompassing the peripheral and central nervous systems. Neurological system involvement may manifest mildly and be reversible in certain circumstances, but a notable percentage of cases have dealt with severe neurological consequences, such as stroke [3].

The results of studies conducted in stroke care units have demonstrated that the pandemic has had detrimental impacts on the patients' administration, particularly concerning central nervous system damage and rehabilitation interventions, even in countries with extensive financial capabilities. It is worth noting that there was a substantial reduction in

hospital visits for strokes during the pandemic. Nevertheless, there was a simultaneous rise in severe cases. The change in hospital admissions suggests a reluctance among individuals to seek emergency medical care. Furthermore, the delayed admission of stroke patients to acute care facilities has negatively affected their overall health and resulted in more complex and prolonged rehabilitation processes [4–6].

A meta-analysis examined the frequency of cerebrovascular events among individuals diagnosed with COVID-19. The investigation revealed that roughly 1.3% of patients exhibited such occurrences. Among these, ischemic stroke was the most commonly observed event [7]. In another meta-analysis, the pooled incidence of acute ischemic stroke was reported to be 1.2% in COVID-19 patients [8]. In contrast, hemorrhagic stroke appears to be less frequent compared to ischemic events. According to Syahrul et al. [9], the pooled prevalence of hemorrhagic stroke was approximately 0.46%, whereas that of ischemic stroke was approximately 1.11%.

Pathophysiological mechanisms of COVID-19-related stroke

Endothelial inflammation

Due to its strong binding to angiotensin-converting enzyme 2 (ACE-2), SARS-CoV-2 has the capability to infiltrate vascular endothelial cells directly. The invasion leads to inflammation inside the endothelial tissues, thereby initiating the process of blood clot formation. Postmortem examinations utilizing tissue samples from various organs have revealed evidence of inflammation and apoptosis in the endothelium cells in individuals with COVID-19 [10, 11]. Following a similar pathway, SARS-CoV-2 can directly infiltrate vascular endothelial cells within the central nervous system. This sequence can result in vasculitis, alterations in the integrity of the blood–brain barrier, and ultimately lead to strokes [12]. Endothelial damage and inflammation are not solely associated with viral invasion. The vascular endothelial structures undergo impairment as a part of the systemic inflammatory reaction triggered by the SARS-CoV-2. This process is also linked to stroke [13].

COVID-19-related hypercoagulation process

Numerous publications have supported the link between COVID-19 and hypercoagulation. Several studies have explored the proclivity toward abnormal blood clotting observed in severe COVID-19 cases, establishing a connection between this hypercoagulable state and factors such as endothelial destruction, heightened inflammation, increased platelet activity, diminished mobility, fluid loss, overactive complement components, and hypoxia [14–16].

Numerous components discovered during the progression of COVID-19 induce coagulation-related mechanisms, initiating the intrinsic and extrinsic coagulation pathways. This results in patients exhibiting clinical symptoms associated with forming arterial and venous thrombosis. Particularly in cases requiring intensive care and extended hospitalization, severe mobility limitations contribute to stagnant blood flow, raising the stroke risk linked to embolisms [17, 18].

Renin–angiotensin–aldosterone system changes associated with COVID-19

Endothelial ACE-2 is a critical part of the renin–angiotensin–aldosterone system, which holds a substantial role in controlling blood circulation within the central nervous system. The interplay between the virus and ACE-2 leads to a decrease in ACE-2 levels, subsequently altering ACE-dependent angiotensin production. This disruption between the classical and alternative renin–angiotensin–aldosterone pathways linked with COVID-19 ultimately results in ischemic conditions due to heightened cerebral vasoconstriction, excessive inflammation, and augmented oxidative stress [19, 20].

Cardiogenic embolism

COVID-19 has been linked to various cardiac system complications, covering myocardial issues, declines in cardiac function, myocardial infarctions, and irregularities in heart rhythm [21]. The systemic inflammatory reaction and the virus's direct harm to heart cells lead to a decline in cardiac functions. This deterioration is further exacerbated by poor lung function and hypoxia. The risk of stroke, particularly in the presence of a hypercoagulable state, is enhanced due to thrombosis in the left ventricle due to reduced heart function [22]. Another notable contributing factor is the heightened frequency of atrial fibrillation resulting from COVID-19 [23]. Moreover, individuals severely affected by COVID-19 appear to be predisposed to recurred bacterial infections. This increased vulnerability to bacteremia and endocarditis among COVID-19 patients may serve as additional risk factors for cardioembolism [24] (Fig. 1).

Stroke in rheumatic diseases

Rheumatic diseases encompass a spectrum of clinical challenges characterized by the presence of joint and connective tissue inflammation. Rheumatic diseases may exhibit manifestations beyond the musculoskeletal system, contingent upon the particular disorder [25]. Potential neurological manifestations of rheumatic disorders have been described [26]. In addition to established risk factors for stroke, several

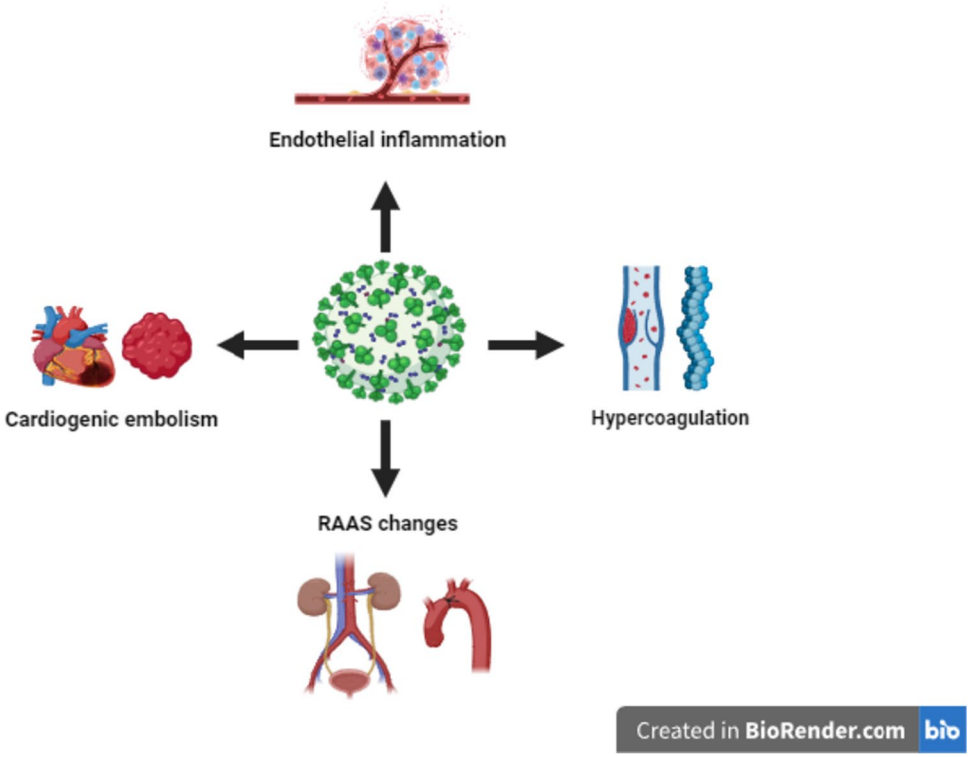

Fig. 1 Pathophysiological mechanisms of COVID-19-related stroke. *RAAS* renin–angiotensin–aldosterone system

investigations have revealed the involvement of inflammation as a precipitating factor [27]. Multiple processes are potentially involved in the development of stroke in rheumatic diseases. Atherosclerosis is a pathological condition characterized by an immune-triggered inflammatory mechanism. The interaction between systemic inflammation and the pathophysiology of rheumatic disorders contributes to the acceleration of vascular atherosclerosis [28]. Systemic rheumatic diseases exhibit a higher frequency of established cardiovascular risk factors. The appearance of endothelial dysfunction plays a pivotal role in the pathogenesis of atherosclerosis. Rheumatic diseases are linked with impaired endothelial function [29, 30]. The administration of pharmaceutical agents for the treatment of rheumatic diseases may contribute to the progression of atherosclerosis. The association between corticosteroids and increased cardiovascular risk has been demonstrated, potentially attributable to factors such as gaining weight, unfavorable alterations in lipid profiles, insulin resistance, and the development of impaired blood sugar regulation [31].

Stroke risk in rheumatic diseases under pandemic conditions

Due to immunological disruption and the intake of immunosuppressive drugs, patients with rheumatic diseases are at an increased vulnerability to COVID-19. Comorbidities in rheumatic diseases have gained exceptional importance since they may be linked to increased risks of hospitalization and mortality in the aftermath of the pandemic [32]. Therefore, patients with rheumatic diseases have encountered considerable obstacles while making decisions regarding behavioral changes aimed at mitigating the potential exposure to COVID-19 [33]. Acute SARS-CoV-2 infection can reveal previously undiscovered rheumatic challenges and cause de novo disease; both may persist after the infection has resolved [34]. The COVID-19 pandemic has resulted in significant interruptions to the provision of healthcare services, leading to the postponement or cancelation of visits, injections, and medical procedures. It has also hindered patients' access to certain anti-rheumatic drugs [35].

Patients with rheumatic diseases may experience a greater propensity to quarantine and reduced physical activity due to concerns about their classification as a higher risk subgroup. The risk of stroke can be heightened in circumstances where there is immobilization and less engagement in exercise-rehabilitation programs. The potential consequence of reduced accessibility to anti-rheumatic drugs is an increased inflammatory load, which may heighten their susceptibility to stroke. A more severe course of COVID-19 in rheumatic diseases may also be linked to stroke [36].

Aim

The previous sections have outlined the connection between COVID-19 and stroke, along with potential mechanisms. Beyond acute care, addressing the sequelae and complications is crucial in stroke management. In this regard, the spotlight shifts to physical medicine and rehabilitation interventions. This article's primary focus is on strategies for stroke rehabilitation within the peri-pandemic conditions. Our aim is to provide a comprehensive overview of the various approaches available for post-stroke rehabilitation within the challenging conditions posed by the COVID-19 pandemic. In addition, we outline how rehabilitation settings have had to adapt and identify the challenges encountered in delivering rehabilitation during the pandemic conditions. Finally, we provide perspectives for the future of neurorehabilitation based on the tremendous lessons and experiences gathered during the pandemic.

Search strategy

Gasparyan et al. [37] provided useful insights into literature review approaches and recommendations in their article. Building upon their guidance, we devised a well-structured literature search strategy for the current article. Our approach adheres to the principles they outlined and incorporates their suggested methods for conducting a comprehensive literature review. In the initial phase, a collection of search phrase combinations was established in the subsequent manner: 'COVID-19 and Stroke' or 'SARS-CoV-2 Infection and Stroke' or 'COVID-19 and Stroke Rehabilitation' or 'SARS-CoV-2 Infection and Stroke Rehabilitation'. We incorporated the existence of Medical Subject Headings (MeSH) terms into our selection of search phrases. We conducted our comprehensive search across databases, including Web of Science, Scopus, PubMed/MEDLINE, and DOAJ. During the evaluation process, the primary emphasis was controlled clinical trials, observational studies, reviews, and English-language articles. To maintain inclusivity, we excluded article types that did not align with our research objectives and any papers that were not pertinent to our topic. In addition, we did not impose any restrictions based on publication dates.

Exercise recommendations in the post-stroke period

Physical activity and exercise have yielded favorable outcomes across various physical, psychological, and social domains in post-stroke individuals. Strong evidence affirms that engaging in exercise following a stroke can enhance cardiovascular health, walking capacity, and upper limb muscle strength [38, 39]. Exercise and rehabilitation interventions are commonly employed to enhance motor impairments in post-stroke individuals. These interventions also provide favorable outcomes regarding psychiatric well-being, memory, and cognitive abilities, quality of life, and fatigue levels [40–42].

Following a stroke, exercise recommendations should be customized to suit the individual's abilities, the phase of their recovery, their physical and social conditions, their personal preferences, and their specific medical status. During the acute phase of stroke, exercise recommendations primarily target the prevention of complications arising from extended periods of immobility, the restoration of voluntary movement, and the enhancement of fundamental activities for daily life. In the acute stroke rehabilitation, it is essential to minimize the amount of time spent in bed. Engaging in activities such as periodic sitting or standing has been shown to effectively reduce the reduction in exercise capacity that may arise during the hospitalization period. The beneficial effects of early mobilization on motor recovery are emphasized [43, 44].

After the patient achieves medical stability, the primary objective is to regain pre-stroke activity levels as much as possible. To achieve this goal, structured exercise and rehabilitation regimens should be created. These interventions can be conducted within inpatient stroke rehabilitation units or under monitored conditions in community or home settings. Physical medicine and rehabilitation interventions are used to improve motor recovery, fine motor abilities, personal care duties, and to support occupational–recreational pursuits [43, 45, 46].

The subsequent phase of stroke rehabilitation involves the development of programming by proficient healthcare practitioners to promote and motivate individuals who have experienced a stroke to sustain an active lifestyle. Thus, the risk of future strokes and cardiac events is reduced. It is imperative to continuously monitor individuals and solicit their comments.

Based on the extant corpus of research, it is recommended that individuals who experienced a stroke integrate aerobic exercise into their daily regimen. Engaging in this activity has the potential to improve one's aerobic capacity and optimize walking performance, hence mitigating the likelihood of experiencing falls, promoting

independence in daily life, and minimizing the probability of recurring cardiovascular problems. Furthermore, it is advisable to incorporate resistance training into one's exercise routine to enhance self-sufficiency in everyday tasks. To enhance the range of motion and mitigate the risk of contractures, it is beneficial to integrate flexibility exercise into one's regimen. Finally, neuromuscular training is recommended to enhance balance and coordination [47–49].

The effectiveness of complex interventions, such as interactive computer applications and kinetic gaming systems, should be evaluated in stroke survivors. The impact of virtual reality and active video games on stroke therapy merits further exploration as they are relatively new treatment techniques. These procedures have the potential to improve arm function and capacity to conduct regular tasks. Gaming experiences that require active participation often engage the lower and upper limbs, leading to moderate increases in the patients' skills [50, 51].

Incorporating yoga and Tai Chi into exercise regimens focused on neuromuscular facilitation and flexibility has been documented to enhance balance and quality of life during stroke rehabilitation and promote mental well-being [52, 53].

Customized neurorehabilitation approaches

In recent years, there has been a considerable increase in neurorehabilitation interventions, corresponding to a shift in the approach to neurological care. The common wisdom that the impacts of brain injuries, such as strokes, are irreversible, including as functional constraints, muscular weakness, mobility challenges, and restricted participation, has been disproved. Instead, there is a rising appreciation for the brain's plasticity and ability to reorganize dynamically. Neurorehabilitation is increasingly focused on managing disturbed brain networks, the impact of intense stimulation, and neural reconfiguration optimization. This section provides an overview of commonly employed approaches within neurorehabilitation [54].

Body-weight-supported treadmill applications

Gait difficulties are a common issue following a stroke. Even with intensive rehabilitation efforts, many stroke survivors continue to grapple with enduring walking impairments [55]. Hence, one of the objectives of stroke rehabilitation is to regain standard walking patterns. Body-weight-supported treadmill therapy is a rehabilitation technique designed to restore physiological walking patterns. This method involves patients walking on a treadmill while receiving partial support for their body weight. A suspension system is employed to ensure stability, typically hung from the ceiling. This approach allows individuals recovering from stroke or other mobility impairments to practice walking in a controlled and supported environment, facilitating the relearning of natural gait movements [56]. Research findings provide evidence for the beneficial outcomes of this system on balance, gait, cardiovascular capacity, and the quality of life among post-stroke individuals [57, 58]. Despite all of its positive effects, it is unclear whether it is superior to traditional physiotherapy procedures, and there are articles reporting effects similar to classical methods [59].

Constraint-induced movement therapy

Constraint-induced movement therapy is a neurorehabilitation approach specifically developed to augment the motor function of the upper extremities after a stroke, with the aim of facilitating its integration into daily activities. The traditional technique involves the immobilization of the unaffected arm and the implementation of task-specific training. Adapted versions of the procedure also impose limitations on the non-affected arm but are not as rigorous as the original protocol [60]. As described in the original protocol, the foundational approach consists of three vital parts. First, it involves implementing rigorous and progressively more challenging exercises for the affected upper limb. These exercises are designed to promote the specific use of the limb in various tasks and are carried out for a duration of up to 6 h per day over a period of 2 weeks. Second, the approach includes constraint therapy, which entails restricting the use of the unaffected upper limb, typically by placing it in a mitt. This restriction encourages the individual to rely on the impaired limb for 90% of their waking hours. Lastly, behavior-enhancing techniques are employed to facilitate the transfer of improvements observed in clinical or laboratory settings to the patient's everyday life [61]. As mentioned before, modified versions are also available.

Despite multiple research confirming the beneficial impacts of the approach in stroke rehabilitation, long-term implications remain unclear. These ambiguities raise concerns about the long-term advantages and sustained improvements that this therapy strategy can provide to stroke survivors. More studies and extended follow-up periods are needed to gain deeper insights into the long-term impact and potential limitations of this approach [62–64].

Robotic rehabilitation interventions

Robotic technology in rehabilitation has shown promise as an effective technique for individuals undergoing stroke rehabilitation. The use of robotic devices in the context of post-stroke rehabilitation presents considerable promise and adaptability. These devices are highly suitable for providing

rigorous, task-oriented motor instruction to a patient's limbs while supervised by a therapist. Frequently, they are incorporated within a full array of rehabilitation techniques that may encompass simpler, non-robotic procedures as well. The integration of these technologies has the potential to optimize the rehabilitation process and exhibit significant potential in enhancing the results of patients recovering from stroke [65, 66]. Robotic systems enhance traditional post-stroke rehabilitation by providing prolonged and consistent therapy sessions that are not susceptible to tiredness. These systems are specifically engineered to offer therapeutic interventions across several functional modalities while integrating multiple automated functionalities. Furthermore, healthcare professionals have the ability to simultaneously observe and record diverse patient behaviors and performance metrics alongside their therapeutic actions [67, 68].

Transcranial direct current stimulation

Transcranial direct current stimulation is used to modulate cortical excitability. It involves the application of a constant and low-level electrical current to the cerebral cortex. This approach entails the administration of a mild electrical current originating from the positively charged electrode (anode) and directed toward the negatively charged electrode (cathode), facilitated by a stimulator device. Anodal stimulation is shown to boost neuronal excitability through the process of depolarization of the cell membrane. Conversely, cathodal stimulation reduces neuronal excitability by inducing cell membrane hyperpolarization [69, 70]. Transcranial direct current stimulation attracted interest at its inception, mainly owing to preliminary research demonstrating its ability to improve neuroplasticity and deliver more significant behavioral improvements [71]. In the context of rehabilitation studies, researchers utilize transcranial direct current stimulation to target specific regions of the scalp with the aim of alleviating pathological disorders. Several studies indicate that transcranial direct current stimulation may benefit chronic stroke recovery, particularly when used in conjunction with traditional rehabilitation procedures [72, 73].

Transcranial magnetic stimulation

Transcranial magnetic stimulation is a nonsurgical technique employed to elicit stimulation in the human brain. Applying an electric current through a coil positioned on the scalp generates a concise and powerful magnetic field. The magnetic field possesses the capacity to traverse the skull and elicit an electric current within the brain, which is capable of initiating the depolarization of neurons and axons. Transcranial magnetic stimulation is a neurostimulation technique that employs a powerful magnetic field to induce localized electrical currents inside targeted regions of the brain [74]. The utilization of specific frequencies achieves the therapeutic objectives of the application. When utilizing high frequencies, usually exceeding 1 Hz, they predominantly produce excitatory effects. In contrast, frequencies below 1 Hz mostly elicit inhibitory effects. The selection of frequency in transcranial magnetic stimulation fundamentally dictates whether it facilitates or suppresses neuronal activity within the specific region of the brain being targeted [75]. Despite the existing obstacle posed by the lack of established standardized protocols and adjustments, transcranial magnetic stimulation has exhibited considerable potential in the field of stroke rehabilitation. It has been linked to positive outcomes [76, 77].

Prism adaptation training

Unilateral spatial neglect can significantly impair an individual's quality of life and physical functioning. The occurrence of unilateral spatial neglect predominantly stems from impairments in the neural pathways responsible for the processing of spatial information and the regulation of attention. The condition is distinguished by the incapacity to accurately perceive, identify, or react to relevant stimuli within the visual field that is opposite to the lesion in the brain, and it is separate from deficiencies in sensory and motor functions [78, 79]. The technique known as prism adaptation is a secure and non-intrusive method that possesses the notable benefit of being easily implementable. During a typical prism adaptation training protocol, participants are equipped with goggles containing prisms and are given instructions to direct their focus on a visual object repeatedly. Individuals may also participate in ongoing manual activities in which their visual perception of their own arm movements is partially obstructed. During the course of the training, it is common for participants to initially make errors in the direction that is influenced by the optical displacement resulting from the prisms. Nevertheless, over time, individuals tend to enhance their accuracy in aiming as they persist in their practices [80]. In this area of study, a consensus has not been reached; most research leans toward considering prism adaptation as a beneficial intervention. However, it is worth noting that some articles present contradictory findings [81].

Reorganization of rehabilitation settings under pandemic conditions

The provision of healthcare services, particularly rehabilitative procedures, has undergone significant transformations due to the global pandemic. In light of the worldwide crisis, rehabilitation services have undergone adaptations and modifications to minimize physical contact between

healthcare personnel and patients while maintaining efficient communication throughout the rehabilitation process [82]. The pandemic-related restrictions imposed to address the crisis resulted in patients having less access to a wide range of rehabilitation treatments, which had unexpected repercussions. Furthermore, even outside of the pandemic environment, the difficulty in obtaining rehabilitative services was a substantial obstacle for those with impairments. This lack of access exacerbated functional limitations for individuals with chronic diseases and slowed recovery after acute events [83].

Prominent indicators indicate that the pandemic has substantially impacted public health in terms of functionality. Given the extensive consequences of COVID-19, encompassing effects on systems such as the neurological and cardiorespiratory functions, and the long-lasting implications of intensive care and extended hospital stays, coupled with the challenges posed by pandemic-related immobility and the long COVID concept, the central emphasis of healthcare services should be the enhancement and reinforcement of rehabilitation services [84, 85].

Under pandemic conditions, it is recommended to divide rehabilitation teams into subgroups, each with the required skills to take over the responsibilities of others if one subgroup is unable to function. Interactions between distinct subteams should be limited while working closely with patients to reduce the risk of infection [86].

A strategy should be developed, considering the hazards associated with infection transmission. This strategy should include adapting rehabilitation facilities to their particular requirements, ensuring the availability of necessary personal protective equipment, implementing thorough disinfection and sterilization procedures, and maintaining social distance between staff and patients during rehabilitation sessions. Rehabilitation services involve a multidisciplinary approach, with medical doctors, physiotherapists, nurses, occupational therapists, nutritionists, social workers, and psychologists collaborating with individual patients. Furthermore, group therapy, in which one or more therapists supervise many patients, is essential to rehabilitation treatments [87, 88].

While there is not an immediate increase in rehabilitation services during a pandemic or other disaster situations, it is evident that there will be a rise in number of patients in the medium to long term. Hence, it is critical to maintain a spacious physical infrastructure for locations offering rehabilitation services. Furthermore, establishing specific rehabilitation departments could be a strategic solution during high patient demand. Rehabilitation centers should create their own emergency plans.

Human resource management is critical in rehabilitation programs. Hiring extra personnel for tasks that can be quickly trained may be necessary. Managers can plan to increase the rehabilitation workforce by creating additional shift schedules and establishing a pool of temporary employees. In addition, reaching out to academic, research, and retired professionals, as well as those now working in non-clinical professions, may be valuable [89].

Telerehabilitation implementation

Telerehabilitation emerges as a critical application within the context of reorganizing rehabilitation services throughout pandemic circumstances. Telerehabilitation exhibits notable potential in addressing the challenges associated with geographical distance, financial constraints, and the scarcity of healthcare services [90]. Instead of relying solely on facility-based rehabilitation, telerehabilitation offers an alternative approach to encouraging physical activity among individuals with stroke who live in the community by allowing them to participate in exercises from the comfort of their own homes using widely available social media applications. According to a systematic review, home-based rehabilitation should be the preferred technique for offering rehabilitation services to patients with stroke in community settings [91].

According to the conclusions of a Cochrane review analyzing the efficiency of telerehabilitation in stroke patients, there is limited or moderate evidence to judge whether telerehabilitation is superior or similarly effective compared to other modes of rehabilitation administration. Moreover, studies investigating the comparative efficacy of telerehabilitation and traditional in-person therapy have not revealed any significant differences in outcomes, suggesting that telerehabilitation does not exhibit inferior effectiveness [92].

Telerehabilitation has been utilized in the domain of neurological rehabilitation to deliver various interventions, including upper and lower extremity training, mobilization-walking training, post-hospital discharge assistance services, and speech therapy [93, 94].

The data collected during the widespread implementation of telerehabilitation in response to the global pandemic have demonstrated favorable results. In the future, telerehabilitation could be integrated into a hybrid structure to provide rehabilitation services. The implementation and sustainability of telerehabilitation within healthcare practice might present various obstacles, such as the need for adequate resources, appropriate infrastructure, and comprehensive training. However, the utilization of telerehabilitation has the capacity to improve the accessibility and equality of rehabilitation services by addressing specific barriers to access. Nevertheless, it is imperative to comprehensively evaluate both patient and service outcomes [95–98].

COVID-19 environment and barriers to rehabilitation

The stroke rehabilitation services experienced difficulties due to the restructuring of healthcare services implemented during the pandemic. The availability of stroke services was impacted in both acute care and community settings. During this period, the primary focus of healthcare services moved to treating COVID-19 patients. Fear of infection, as well as tight quarantine procedures, had a considerable impact on healthcare operations. Some patients voiced concerns about home visits after being discharged due to their fear of infection. As a result, it was not unexpected for therapists to see a drop in stroke unit admissions and referrals to community resources. The stroke units and rehabilitation centers underwent conversion into COVID-19 units. The abovementioned issue has also led to insufficient rehabilitation equipment and a dearth of physical areas designated for rehabilitation. During the implementation of quarantine measures, stroke patients encountered a state of deconditioning due to their inability to participate in mobility exercises and the absence of social interaction. Consequently, their susceptibility to developing mental and emotional issues was heightened. Thus, certain patients exhibited reluctance about engaging in rehabilitation. Personnel redistribution took place at various levels, where stroke therapists and nurses were reassigned to work in COVID-19 wards. This redistribution significantly disrupted rehabilitation services. Patients faced mental and physical difficulties due to the lack of family support, while therapists observed a decrease in family involvement in patient care and rehabilitation processes [99–101].

Future perspectives of neurological rehabilitation after the pandemic

The pandemic has exerted a substantial influence on the domain of neurological rehabilitation, leading to notable modifications within the field. The following are potential future viewpoints about neurological rehabilitation after the COVID-19 pandemic (Fig. 2).

The utilization of telehealth and telerehabilitation services notably increased due to the pandemic. This tendency will probably persist and undergo further expansion in the future. Remote rehabilitation sessions can be provided to patients, hence decreasing the necessity for in-person visits. This intervention is particularly advantageous for individuals who experience limited mobility or reside in geographically isolated regions.

Home-based rehabilitation programs are becoming increasingly popular. Patients can track their progress and engage with healthcare practitioners using technological devices and wearable gadgets. This enables more personalized and ongoing care.

Data analytics and artificial intelligence are increasingly being used by rehabilitation programs to customize treatment strategies. Machine learning algorithms can examine patient data in real-time and alter rehabilitation exercises as needed.

The pandemic has highlighted the value of addressing mental health issues in neurological rehabilitation. Physical medicine and rehabilitation specialists and therapists will pay greater attention to the emotional wellness of patients and integrate mental health care into rehabilitation regimens.

Neurorehabilitation research will continue to yield novel treatments and techniques. Scientists will focus on

Fig. 2 Future perspectives of neurological rehabilitation after the pandemic

neuroplasticity and other factors to develop more effective treatments.

Recognizing that these viewpoints may exhibit variation based on geographical location and the specific healthcare system is essential. The trajectory of neurological rehabilitation in the coming years will be contingent upon technological advancements, shifts in healthcare regulations, and the dynamic requirements of patients.

Conclusion

The COVID-19 pandemic generated global shockwaves, profoundly impacting societies and healthcare systems. The importance of rehabilitation implementations became apparent as the first shock wore off. Despite the difficult circumstances, healthcare providers worked hard to maintain rehabilitation programs. Notably, remote access and the adoption of telerehabilitation emerged as critical technologies, allowing essential services to reach patients without exacerbating the spread of the virus.

This experience has taught us important lessons, notably about reorganizing rehabilitation centers to navigate crises efficiently. Looking ahead, the field of neurorehabilitation will benefit from continued growth, with a strong emphasis on harnessing technology. Remote access and telehealth, which were critical during the pandemic, are projected to become far more crucial in the future. Furthermore, artificial intelligence technologies offer considerable promise in potentially reinventing how rehabilitation is delivered and adapted to individual needs. Neurorehabilitation is set to evolve as the world adjusts to new challenges, ensuring that patients receive the care they require swiftly and effectively, independent of external circumstances.

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Declarations

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REVIEW

Telerehabilitation: lessons from the COVID-19 pandemic and future perspectives

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Abstract

The coronavirus disease 2019 (COVID-19) pandemic has had an enormous effect on healthcare, notably rehabilitation for neurological, rheumatological, musculoskeletal, and cognitive diseases. Telerehabilitation provides rehabilitation services via multiple modalities, such as real-time chats, computerized consultations, and distant evaluations, emphasizing assessment, diagnosis, and intervention. While the use of telerehabilitation had restrictions before COVID-19, regulatory changes have accelerated its adoption, broadening therapy provision beyond traditional healthcare settings. Telerehabilitation has been examined for its effectiveness in a variety of health concerns, including stroke, traumatic brain injury, Parkinson's disease, musculoskeletal disorders, and rheumatic diseases. Despite the constraints of the COVID-19 environment, telerehabilitation settings, which include patient and therapist aspects, have emerged to ensure optimal treatment delivery. Key themes include home-based rehabilitation initiatives, wearable gadgets, and the integration of analytics and artificial intelligence. The growing acceptance of telehealth and telerehabilitation is expected to drive further progress in this discipline.

Keywords Telerehabilitation · Remote rehabilitation · Virtual rehabilitation · Telemedicine · COVID-19 · Rheumatic diseases

Introduction

The absence of regular rehabilitation care for neurological, rheumatological, musculoskeletal, and cognitive disorders can lead to various negative consequences involving functional impairment, diminished quality of life, psychological anguish, and disease progression [1]. The detrimental consequences of social distancing may be even more severe for specific patient groups, as they need continual monitoring to lessen the disease's burden [2].

The coronavirus disease 2019 (COVID-19) pandemic has profoundly impacted all facets of healthcare provision. Various measures have been implemented to facilitate the extensive adoption of telecommunication technology as a substitute for face-to-face medical consultations to mitigate viral transmission and preserve the well-being of healthcare practitioners, patients, and the general public. These efforts encompass modifications to rules, regulations, and financing policies [3]. Telerehabilitation interventions have become prominent in searching for solutions to the pandemic's challenges [4].

Aim

This article aims to provide a definition of telerehabilitation and elucidate its extent. The secondary objective is to address the efficacy of telerehabilitation and highlight its application in rheumatic diseases. The article focuses on

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the evolution of telerehabilitation practices in COVID-19. Finally, the future of telerehabilitation is underlined in light of the lessons of the COVID-19 pandemic.

Search strategy

Before executing the literature review, a search strategy was devised that corresponded with the criteria proposed by Gasparyan et al. [5]. The presence of Medical Subject Headings (MeSH) terms was considered throughout the search phrase selection procedure. Search phrase combinations are determined as follows: 'Telerehabilitation and Clinical Efficacy' or 'Remote Rehabilitation and Clinical Efficacy' or 'Telerehabilitation and Rheumatic Diseases' or 'Remote Rehabilitation and Rheumatic Diseases' or 'Telerehabilitation and Coronavirus Disease-19' or 'Remote Rehabilitation and Coronavirus Disease-19' or 'Telerehabilitation and COVID-19 Pandemic' or 'Remote Rehabilitation and COVID-19 Pandemic'. The Web of Science, Scopus, PubMed/MEDLINE, and DOAJ were used to list the publications. Controlled clinical trials, observational studies, review articles and publications written in English were considered for our evaluation. Articles that were not pertinent to the subject matter were excluded. The articles were evaluated without considering the publishing date, and no specific time frame was specified.

Telerehabilitation

Telerehabilitation pertains primarily to the provision of clinical rehabilitation services that prioritize the processes of assessment, diagnosis, and intervention. Telerehabilitation encompasses a range of modalities for delivering care, such as reciprocal conversations in real-time incorporating audio, video, or combination; electronic consultations; virtual notifications; faraway assessments of stored videos, photos, or radiologic images; and telephone-based handling and management operations [6]. The use of telerehabilitation in various health systems was restricted by disparities and limitations in state rules and reimbursement policies of governments and insurers until the advent of COVID-19 strategies necessitated the adoption of safer provision alternatives. Telerehabilitation for physical therapy has been permissible in certain situations due to recent laws, regulations, and reimbursement modifications. This development has created an exceptional avenue for researching the implementation and consequences of telerehabilitation [7]. Telerehabilitation broadens the range of therapeutic services, transcending traditional healthcare settings. It facilitates care delivery outside the conventional healthcare framework, enabling a care delivery strategy for minimizing the harmful effects of physical remoteness on access to therapy. It provides benefits in terms of both quantitative and qualitative factors influencing outcomes after therapy [8]. The advantages of telerehabilitation are summarized in Fig. 1.

Efficacy of telerehabilitation

Telerehabilitation presents an alternative strategy for promoting physical activity among individuals residing in the community instead of exclusively relying on facility-based rehabilitation. This approach enables individuals to engage in exercise routines from the convenience of their own homes, utilizing readily accessible social media applications. Based on a comprehensive analysis, it is recommended that home-based rehabilitation be prioritized as the optimal approach for delivering rehabilitation services to individuals with stroke in community environments [9].

Telerehabilitation has been subject to evaluation concerning a diverse range of health issues to determine its efficacy. Stroke survivors are one of them. Based on the findings of a

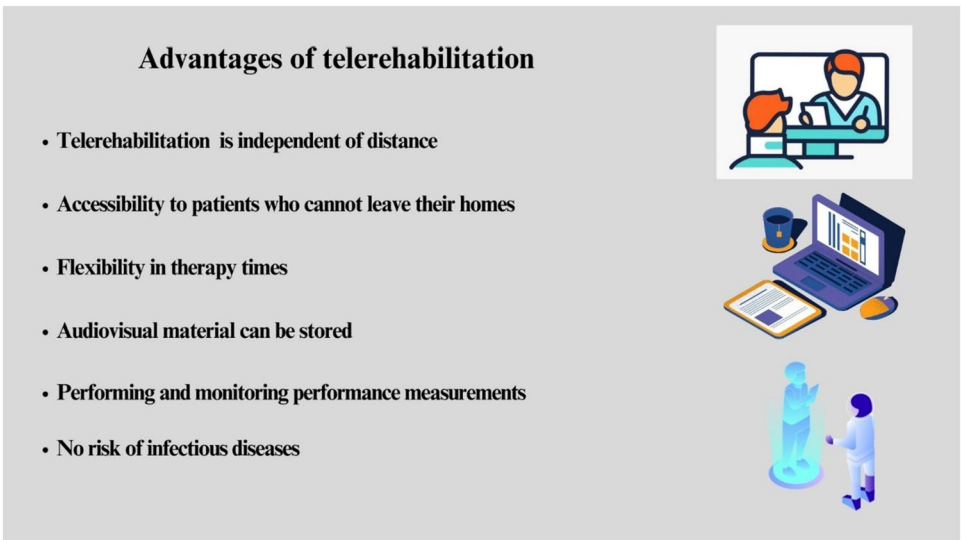

Fig. 1 Advantages of telerehabilitation

Cochrane review, which examined the efficacy of telerehabilitation in individuals recovering from stroke, the available data is limited or moderate. Consequently, it is challenging to determine if telerehabilitation is superior or equally effective compared to alternative rehabilitation intervention delivery methods. Furthermore, research comparing the effectiveness of telerehabilitation and conventional face-to-face therapy has not identified any substantial disparities in outcomes, indicating that telerehabilitation does not demonstrate inferior efficacy [10, 11]. There is a body of systematic reviews that provide support for the efficacy of telerehabilitation as an approach in the treatment of traumatic brain injury and Parkinson's disease [12, 13].

Furthermore, telerehabilitation has demonstrated its worth as a vital resource for enhancing the continuity of healthcare. Patients can smoothly shift from face-to-face therapy sessions to virtual encounters, guaranteeing continuous rehabilitation. This not only improves patient adherence but also contributes to better long-term results. Research has demonstrated that telerehabilitation can be equally successful as conventional in-person rehabilitation, resulting in enhancements in many health parameters [14, 15].

Telerehabilitation is not limited to any particular type of disorder; it encompasses a wide range of rehabilitation requirements. Telerehabilitation has proven effective in various scenarios, including supporting post-surgical recovery, managing chronic conditions, and facilitating rehabilitation after injury. By integrating wearable devices and sensors, the monitoring capabilities are substantially enhanced, enabling healthcare practitioners to collect real-time patient activity and progress data. This consequently allows for more accurate customization of therapies [16–18].

Telerehabilitation and rheumatic diseases

By virtue of its technological infrastructure, telerehabilitation offers a pioneering resolution to the rehabilitation requirements of patients with rheumatic diseases. Numerous investigations have been conducted regarding rheumatic diseases and musculoskeletal disorders. The use of telehealth services has the potential to enhance both the accessibility and continuity of healthcare for individuals suffering from rheumatic diseases. This is particularly beneficial for patients confined to their homes, reside in geographically isolated regions, belong to disadvantaged groups, or must adhere to social distancing regulations [19]. A meta-analysis was conducted to assess the efficacy of real-time telerehabilitation in managing different musculoskeletal disorders. The findings indicate that when telerehabilitation is used with usual care, it yields better outcomes than usual care alone. Additionally, treatment exclusively delivered through telerehabilitation is as effective as in-person intervention in improving physical abilities [20]. The findings of a meta-analysis on fibromyalgia syndrome indicate that it has the potential to yield favorable outcomes in terms of symptom management and improvement in overall quality of life [21]. The efficiency of telemedicine in the context of rheumatic disorders was assessed by a systematic review encompassing randomized controlled clinical studies, systematic reviews, and non-randomized controlled clinical studies. Trials focused on rheumatoid arthritis and systemic lupus erythematosus. The findings provide evidence in favor of the potential beneficial impacts of telerehabilitation [22]. A systematic review aimed to analyze existing evidence on the efficacy of telehealth procedures in facilitating self-management for individuals with rheumatoid arthritis. According to this review, telehealth interventions that are well-planned, customized, and comprehensive can contribute to achieving favorable self-management results in rheumatoid arthritis [23]. During the pandemic, voice-based teleconsultations were reported to be beneficial in identifying and managing common relapses in inflammatory myopathies [24].

Telerehabilitation platforms provide remote consultations with rheumatologists, physical medicine and rehabilitation specialists, physiotherapists, and occupational therapists, guaranteeing that patients with rheumatic diseases receive competent counsel and customized rehabilitation programs, irrespective of their geographical location. Through virtual consultations and remote monitoring, healthcare practitioners can evaluate patients' joint functionality, pain intensity, and overall mobility. This information enables the development of personalized exercise programs and rehabilitation strategies that consider each patient's distinct requirements and difficulties. Continuous monitoring is essential for adapting treatments to the ever-changing characteristics of rheumatic diseases and ensuring that patients receive prompt revisions to their treatment plans. With ongoing advancements in technology, telerehabilitation is positioned to have a crucial impact on improving care for patients with rheumatic diseases [19, 25].

COVID-19 surroundings and rehabilitation obstacles

The rehabilitation services encountered challenges due to the reorganization of healthcare services implemented during the pandemic. The provision of services was affected in both acute care and community-based settings. The apprehension regarding the spread of infections, coupled with stringent quarantine protocols, significantly influenced the operations of hospitals. During the execution of quarantine procedures, individuals with disabilities experienced a state of deconditioning as a result of their limited ability to engage in exercises and the lack of social connection. As a result, their vulnerability to the development of mental and emotional disorders was increased. Thus, a subset of patients demonstrated hesitancy about participating in the

rehabilitation process. Patients had both mental and physical challenges as a result of inadequate familial support. At the same time, therapists noted a decline in the level of family engagement in patient care and rehabilitation procedures [26–28].

Telerehabilitation settings

The optimal rehabilitation setup should incorporate maximum mobility and intelligence from the patient's perspective, with the greatest effectiveness on the medical professional's part. In the context of healthcare, medical equipment and electronic infrastructure have conventionally served a crucial role in facilitating telemedicine. After the identification of the target medical disorder and the establishment of the telemedicine approach, physicians are required to make a selection of appropriate medical equipment and systems for implementation. Furthermore, providing patients with appropriate guidance in this matter is imperative [29].

The key elements constituting the patient setting encompass an electronic device connectivity to the internet, equipment designed for audio–visual display, and sensors that interface with the device to monitor and observe the individual's performance and progress [8, 30]. The most suitable telerehabilitation setting should encompass the provision of data on patients. The implementation of in-depth monitoring of patient outcomes is necessary to validate compliance with treatment protocols, guarantee patient safety, and assess the progression of recovery. The initial two attributes can be implemented entirely by employing teleconferencing technologies. However, it is essential to incorporate dedicated monitoring equipment into the rehabilitation system to assess recovery progress objectively. This is accomplished by evaluating tiny patient performance alterations [31, 32] (Fig. 2).

After establishing the patient's surroundings, it is essential also to consider the therapist's setting. This refers to the structural framework that enables the home-based configuration to receive treatment administration data and transmit patient progress data [33].

Future perspectives of rehabilitation following the pandemic

The COVID-19 pandemic has engendered a worldwide crisis and profoundly impacted several facets of human existence and activities [34]. The pandemic has led to a substantial acceleration in the adoption of telehealth and telerehabilitation options. This inclination will likely continue and experience additional growth in the future. Remote rehabilitation procedures have the potential to be administered to patients, hence reducing the need for face-to-face appointments. This technique confers notable benefits to those who encounter

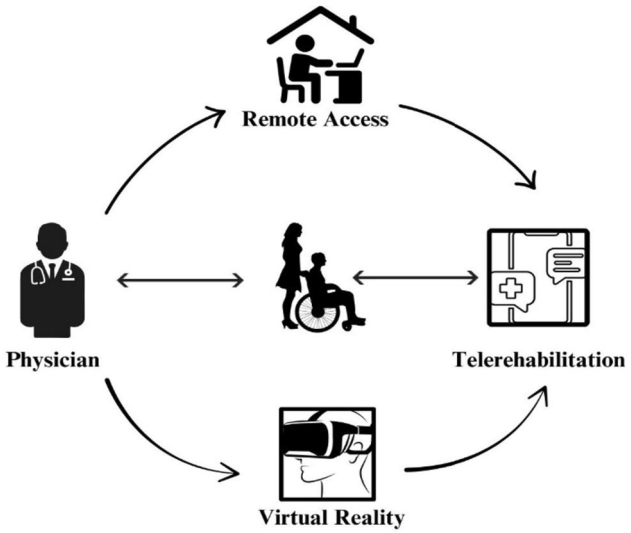

Fig. 2 Demonstration of a telerehabilitation setting

restricted mobilization or dwell in geographically secluded areas [35].

Home-based rehabilitation initiatives are gaining popularity. Patients can use wearable electronic devices and gadgets to monitor their development and communicate with healthcare providers. This allows for more customized and continuous care [36, 37].

Rehabilitation programs are progressively incorporating analytics of data and artificial intelligence to tailor treatment strategies. Algorithms based on machine learning provide the capability to analyze patient data in real time and adjust rehabilitation programs as necessary [38].

Conclusion

The COVID-19 pandemic has elicited widespread global repercussions, profoundly influencing society and healthcare systems [39]. The significance of implementing rehabilitative measures became evident once the first shock subsided. Notwithstanding the challenging circumstances, healthcare providers diligently managed rehabilitation programs. Significantly, the utilization of remote access and the integration of telerehabilitation have emerged as pivotal technological advancements, enabling the provision of vital treatments to patients while mitigating the risk of viral transmission. The utilization of remote access and telehealth services, which played a vital role during the pandemic, is anticipated to gain even greater significance in the coming years. Moreover, artificial intelligence technologies hold significant potential in revolutionizing the delivery and customization of rehabilitation according to individual needs.

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Declarations

Conflict of interest The authors declare no conflicts of interest.

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OBSERVATIONAL RESEARCH

Healthcare professionals' knowledge and perceptions of post-stroke rehabilitation in the peripandemic period: an online cross-sectional survey

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Abstract

The COVID-19 pandemic has profoundly affected healthcare systems, particularly post-stroke rehabilitation centers. The elevated severity of strokes and delayed hospital admissions caused numerous hurdles to rehabilitation administration during the peri-pandemic period. This study surveyed healthcare professionals' knowledge and perceptions of post-stroke rehabilitation during this period. An online cross-sectional survey was administered from September 17, 2023 to February 23, 2024, utilizing the SurveyMonkey platform. The questionnaire included 30 questions addressing participant baseline characteristics, knowledge of definitions and experiences, post-stroke rehabilitation procedures, obstacles encountered during the peri-pandemic period, and the utilization of telerehabilitation. Only complete responses from health professionals were considered. This report utilized convenience sampling. Data were analyzed via descriptive statistics and chi-square tests, with a significance threshold of $p < 0.05$. A total of 79 health professionals, predominantly physiatrists, neurologists, and physiotherapists, from eight countries participated in the study. Over half of the participants (64.6%) indicated the existence of a dedicated department for post-stroke rehabilitation. Significant obstacles comprised an absence of advanced rehabilitative treatments (60.8%), inadequately skilled workers (50.6%), and restricted space for rehabilitation (46.8%). Telerehabilitation was regarded as a feasible option by 45.6% of participants; nonetheless, obstacles, including patients' telecommunication proficiency and the possibility of diagnostic inaccuracies, were acknowledged. Complementary therapies, such as music and dance therapy, received favorable evaluations from 67.1% to 63.3% of respondents, respectively. The pandemic reduced rehabilitation admissions due to infection concerns (75.9%) and increased multimorbidity cases among patients (48.1%). The study underscores the pandemic's negative effect on post-stroke rehabilitation, emphasizing the necessity for multidisciplinary, customized therapy and enhanced integration of telerehabilitation to overcome access barriers. Addressing obstacles regarding infrastructure, training, and access to advanced approaches, particularly in a post-pandemic context, is essential to improving rehabilitation outcomes.

Keywords COVID-19 · Stroke rehabilitation · Neurological rehabilitation · Telerehabilitation · Surveys and questionnaires

Introduction

The 2019 coronavirus disease (COVID-19) has profoundly affected nations, economies, and health systems worldwide. Since late 2019, COVID-19 has expanded rapidly, resulting in millions of infections and fatalities globally. The virus has not only posed substantial public health risks, but it has also caused broad social and economic upheaval [1–3]. While the focus of COVID-19 is on the respiratory system, it has a wide range of effects, including those on peripheral and central neurological systems. While some cases have shown modest and curable neurological signs, a considerable proportion have had severe complication, such as stroke. COVID-19 has been linked to an increased risk of stroke, possibly due to the virus's tendency to induce a hypercoagulable state and inflammation [4, 5].

Extended author information available on the last page of the article

Research conducted in stroke-related units has revealed that the pandemic has had profound and debilitating effects, even in regions with adequate financial means, especially in terms of neurological rehabilitation procedures [6]. During the pandemic, hospital appointments for stroke decreased significantly. However, this decrease coincided with an increase in serious cases. This shift in hospital admissions implies a concerning hesitation among patients to seek emergency medical care during a period when the pandemic was so severe [7, 8]. Furthermore, delayed admission of stroke patients to acute care institutions has had an enormous effect on overall health outcomes, resulting in more challenging and extended rehabilitation processes. The combination of these factors highlights the critical need for public health activities to alleviate anxieties about seeking medical care during the pandemic while also ensuring timely access to critical stroke therapies and rehabilitation services for optimal patient outcomes [4, 9].

The restructuring of the health care system has brought challenges in the delivery of stroke rehabilitation. The accessibility of stroke-related services has been affected at both hospital and community levels. At this stage, health services are primarily focused on addressing COVID-19 patients. The infection concern and tight quarantine standards had tremendous effects on rehabilitation [10, 11].

The convergence of COVID-19, rheumatic disorders, and stroke offers a crucial viewpoint, as individuals with rheumatic diseases may encounter increased risks stemming from the inflammatory characteristics of their disorders and the effects of COVID-19. The hyperinflammatory statet caused by COVID-19 is associated with a heightened risk of thromboembolic events, including stroke, especially in individuals with pre-existing autoimmune rheumatic disorders [12, 13]. These patients frequently have a susceptibility to coagulopathy owing to persistent inflammation and concomitant comorbidities, including cardiovascular disorders [14]. Patients with rheumatic disorders may experience additional obstacles during post-stroke rehabilitation, such as impaired mobility, joint damage, and tiredness, all of which may impede rehabilitation. The pandemic worsened these concerns by delaying rehabilitation programs and imposing barriers to obtaining care [4].

The current multidisciplinary and international study aims to survey healthcare professionals' knowledge and perceptions of post-stroke rehabilitation during the peri-pandemic period.

Methods

This survey was designed using pertinent reviews and practice guidelines [15–17]. Relevant survey reports were consulted during the questionnaire drafting [18–20]. A group of five physical medicine and rehabilitation specialists (physiatrists), rheumatologists, and neurologists checked the form's clarity, completeness, and face validity. The group tested the preliminary version of the questionnaire. Their feedback was assessed, and the questionnaire was revised twice. The questionnaire required, on average, 15 min to complete.

The final version of the questionnaire (Appendix 1) included a total of 30 questions, 26 of which were multiple-choice,. 3 Likert-style, and 1 open-ended question. The questionnaire was divided into the following four sections: fundamental points on the concept of post-stroke rehabilitation, main issues, specifics in the peri-pandemic period, and socio-demographic information. The questionnaire was released on the SurveyMonkey.com platform and disseminated via X (Twitter) and Facebook from September 17, 2023 to February 23, 2024.

The survey protocol was reviewed and approved by the Local Ethics Committee of South Kazakhstan Medical Academy, Shymkent, Kazakhstan (protocol N4, dated March 31, 2022). Written informed consents were obtained from all voluntary participants. No incentives were offered for this survey. The respondents could change their answers before submission but not after it. All questions were mandatory. The survey was completely anonymized. Only completed forms were processed. The respondent's data were anonymized and kept confidential. Duplicate entries were avoided by the SurveyMonkey.com platform with its proprietary control system. Only entries from individuals who identified themselves as health professionals and completely responded to all questions were processed. This report employed convenience sampling and adhered to the widely publicized recommendations on designing and reporting surveys [21–23].

Statistical analyses

The descriptive statistics are reported in absolute numbers and percentages. Microsoft Excel was utilized to generate figures. Chi-square tests were employed to compare responses between groups. The results were deemed statistically significant at a p value of less than 0.05. The statistical analysis was conducted with Microsoft Excel.

Results

Baseline characteristics of participants

The questionnaire was completed by 79 responders, with a median age of 38 (26–70) years, 52 females and 27 males. Sixty-seven participants had more than five years of professional experience, 9 participants 1–5 years, and 3 participants less than one year. Notably, 54 participants reported more than 5 years of post-stroke rehabilitation experience, 15 participants 1–5 years, and 10 participants less than one year. The responders identified themselves as physiatrists ($n=55$), neurologists ($n=7$), and physiotherapists ($n=6$). The highest number of participants were from Türkiye ($n=58$), Kazakhstan ($n=6$), and Ukraine ($n=6$). There were also participants from the United Kingdom, Germany, Croatia, Jordan, and Bulgaria.

Thity-four (43.1%) participants were employed at public inpatient rehabilitation clinic, 9 (11.4%) at public inpatient neurology clinic, 9 (11.4%) at private inpatient rehabilitation clinic, 8 (10.1%) at private outpatient rehabilitation clinic, 5 (6.3%) at public outpatient neurology clinic, and 5 (6.3%) at both public and private stroke rehabilitation clinics. In addition, 9 (11.4%) participants were from other clinics. Forty-six (58.2%) participants were involved in teaching.

Rehabilitation environment

Fifty-one (64.6%) respondents reported having a specialized department/unit for post-stroke rehabilitation in their healthcare setting. The location of the place of health care provision for rehabilitation after stroke was reported as urban by 75 (94.9%) respondents. The main problems/barriers to the implementation of effective post-stroke rehabilitation were the following: lack of advanced rehabilitation techniques ($n=48$; 60.8%), lack of trained healthcare professionals (physicians and nurses) ($n=40$, 50.6%), insufficient space ($n=37$, 46.8%), and inadequate training of stroke and allied specialists ($n=23$, 29.1%).

Knowledge about definitions and participant experience

Fifty-five (69.6%) participants were familiar with the definition of stroke rehabilitation introduced by the Medical Subject Headings (MeSH) of the National Library of Medicine of the U.S. In the previous year, 44 (55.7%) participants managed more than 5 post-stroke patients per month, while 26 (32.9%) managed 1 to 5 patients per month. Importantly, 38 (48.1%) participants were engaged in stroke-related rehabilitation research, clinical trials, stroke registry reporting, and systematic or narrative review writing.

Post-stroke rehabilitation management

The clinical issues addressed during post-stroke rehabilitation are illustrated in Fig. 1. The top three were reduced functional independence ($n=77$, 97.5%), immobility ($n=76$, 96.2%), and depression ($n=72$, 91.1%). The group members that should be engaged in the rehabilitation of patients to achieve the goal of maximum function restoration are listed in Fig. 2. The top three were physiotherapists ($n=75$, 94.9%), patients ($n=73$, 92.4%), and physiatrists (72, 91.1%). Family members and rehabilitation nurses were also mentioned as post-stroke rehabilitation team members ($n=72$, 91.1% for both).

Seventy-five (94.9%) participants agreed that stroke rehabilitation should be organized in specialized clinics with access to multidisciplinary care. Only 2 (2.5%) participants thought that it should be organized in neurology clinics, and only 1 (1.3%) thought it should be organized at home.

The list of participant-endorsed anticoagulation strategies for immobilized patients after stroke is presented in Fig. 3. The clinical situations that should be discussed with

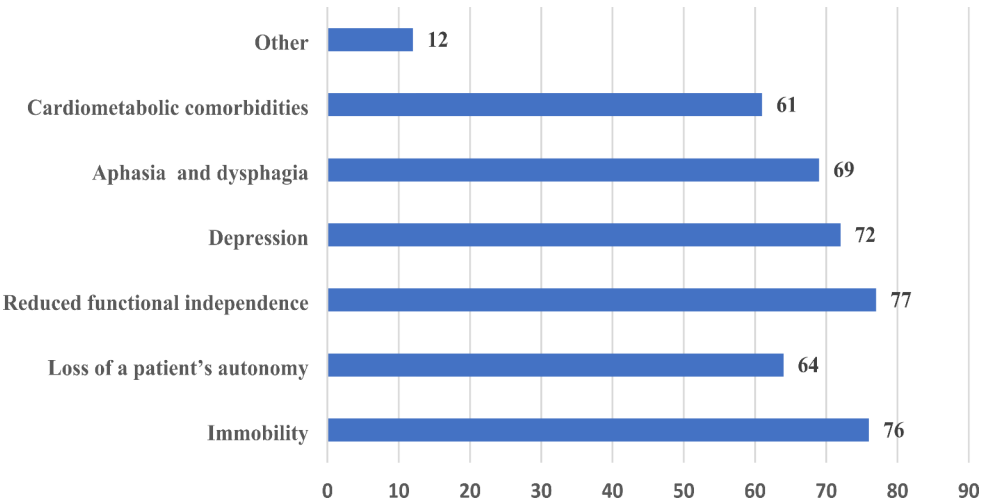

Fig. 1 Clinical conditions or diseases that should be managed during post-stroke rehabilitation

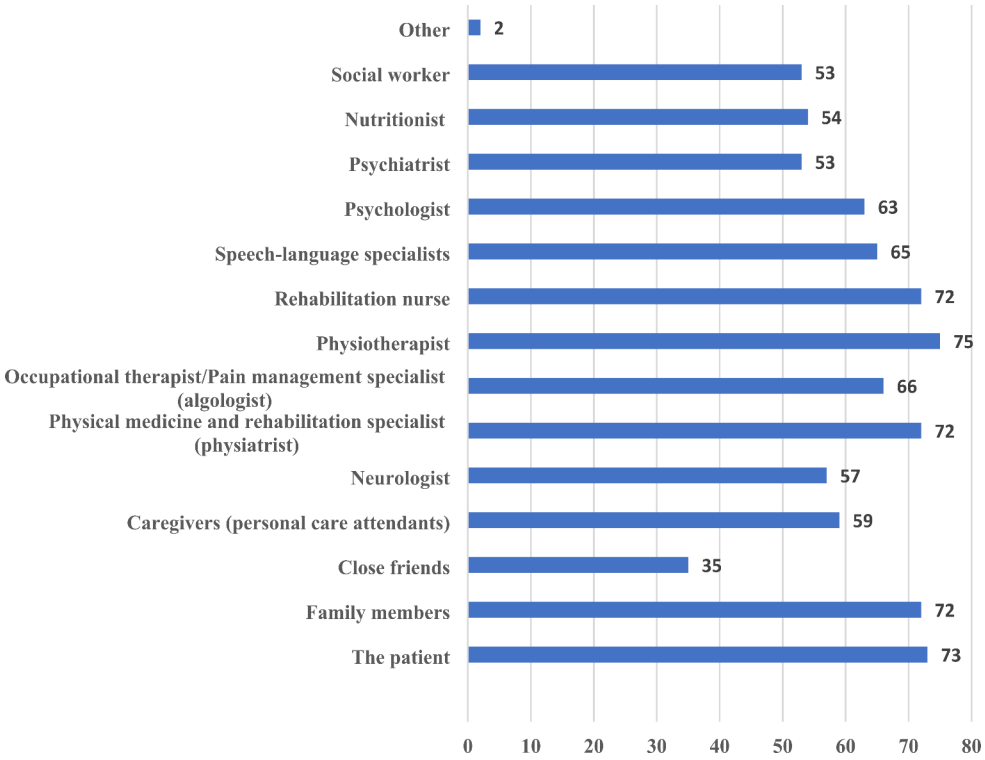

Fig. 2 Team members that should be included in post-stroke rehabilitation

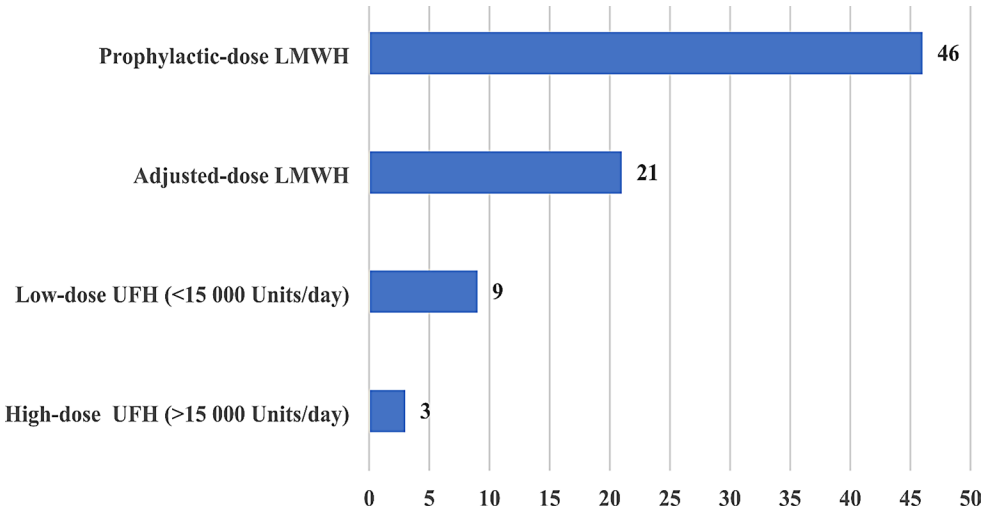

Fig. 3 Anticoagulation strategies for immobilized patients after stroke. LMWH: Low-molecular-weight heparin; UFH: Unfractionated heparin

patients after a stroke are shown in Fig. 4. Participants prioritized efforts directed toward impaired cognitive functions and memory loss ($n=77$, 97.5%), post-stroke spasticity and involuntary movements ($n=77$, 97.5%), dysarthria and apraxia of speech ($n=75$, 94.9%), balance impairment and ataxia ($n=75$, 94.9%), and sleep disorders ($n=75$, 94.9%).

Participants also mentioned cardiovascular risk reduction as part of post-stroke rehabilitation (Fig. 5). Increasing physical activity was the most often mentioned option ($n=73$, 92.4%).

Table 1 shows clinical conditions improving after post-stroke rehabilitation. The sum of the numbers "strongly agree" and "agree" is considered. The number of participants who reported that post-stroke rehabilitation had a positive contribution to sensory functions was 68 (86.1%), cognitive functions 66 (83.5%), motor functions 74 (93.7%), balance 72 (91.1%), and sexual functions 33 (41.8%).

The frequency of rehabilitation modalities utilized during post-stroke rehabilitation was also assessed. Constraint-induced movement therapy ($n=23$, 29.1%) and orthotic-prosthesis applications ($n=23$, 29.1%) emerged as prominent in regular use. The most unavailable modalities were transcranial direct current stimulation ($n=53$, 67.1%), transcranial magnetic stimulation ($n=53$, 67.1%), and robotic rehabilitation applications ($n=36$, 45.6%) (Table 2).

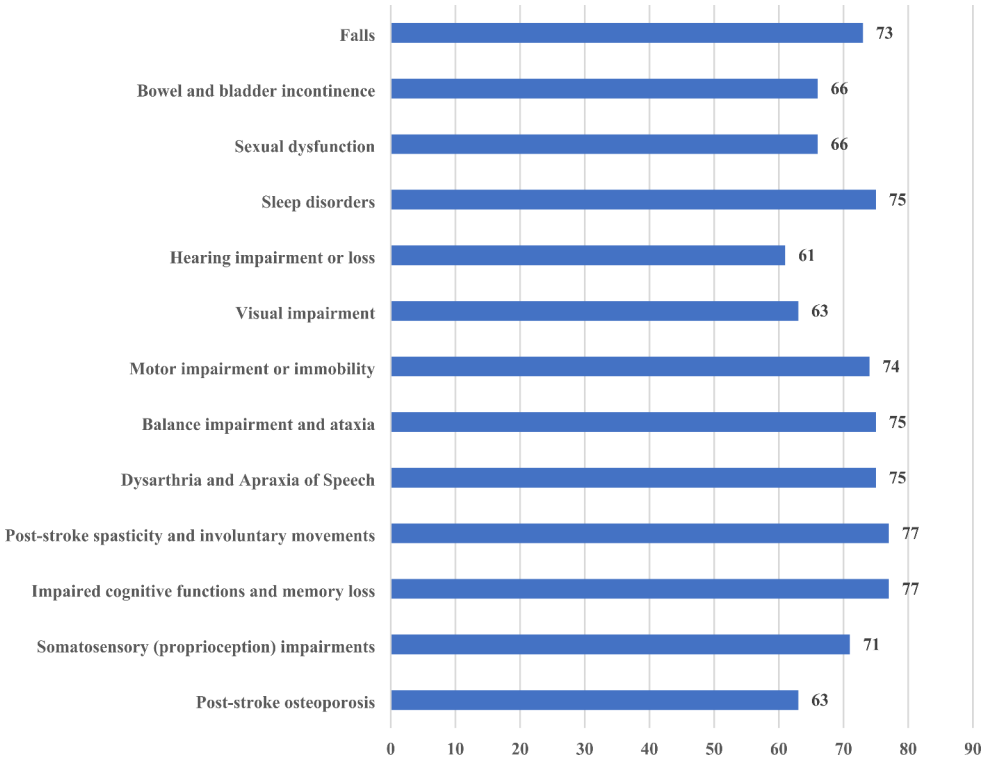

Fig. 4 The clinical situations that should be discussed with patients after stroke

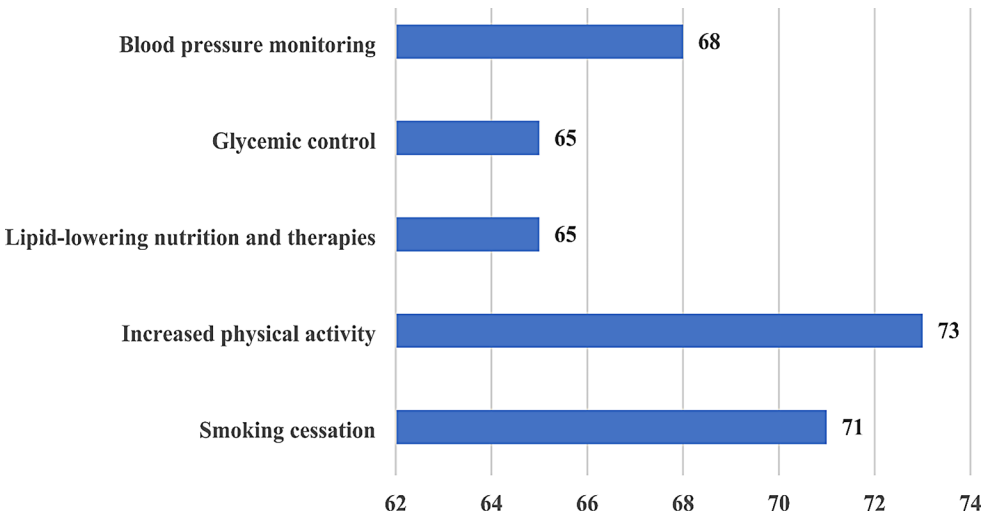

Fig. 5 Cardiovascular risk reduction strategies for rehabilitation after stroke

Table 1 Participants' level of agreement with the benefits of the use of post-stroke rehabilitation

Level of agreement	Sensory functions (*n*)	Cognitive functions (*n*)	Motor functions (*n*)	Balance (*n*)	Sexual functions (*n*)
Disagree	2	1	2	2	5
Strongly disagree	3	6	3	4	5
Neutral	7	6	0	1	36
Agree	29	34	15	25	21
Strongly agree	39	32	59	47	12

n: number

Based on the sum of "strongly agree" and "agree" responses, music therapy ($n=53$, 67.1%), dance therapy ($n=50$, 63.3%), and massage therapy ($n=38$, 48.1%) were endorsed as important complementary modalities (Table 3).

Stroke rehabilitation in the COVID-19 pandemic

A total of 51 participants (64.6%) referred COVID-19 survivors to post-stroke rehabilitation. The extent to which the COVID-19 pandemic has impacted post-stroke rehabilitation was mentioned as significant by 36 (45.6%) participants. Decreased admission to post-stroke rehabilitation

Table 2 Modalities use frequency in post-stroke rehabilitation

Rehabilitation modality	Not available (*n*)	Available but not used (*n*)	Rarely used (*n*)	Sometimes used (*n*)	Regularly used (*n*)
Constraint-induced movement therapy	8	12	13	23	23
Constraint-induced language therapy	32	4	19	19	5
Weight-supported treadmill training	17	5	15	33	9
Transcranial magnetic stimulation	52	10	8	5	4
Transcranial direct current stimulation	53	11	5	5	5
Robotic rehabilitation applications	36	4	15	13	11
Dysphagia rehabilitation	22	9	24	17	7
Orthotic-prosthesis applications	10	5	15	26	23
Biofeedback therapy	25	8	26	12	8

n: number

Table 3 Participants' agreement on the benefits of complementary therapies in stroke rehabilitation

Complementary therapy	Strongly disagree (*n*)	Disagree (*n*)	Neutral (*n*)	Agree (*n*)	Strongly agree (*n*)
Acupuncture	7	18	29	20	5
Massage therapies	3	11	27	34	4
Dance therapy	0	3	26	46	4
Music therapy	1	3	22	45	8
Ozone therapy	2	15	43	13	6
Cupping	20	21	33	4	1
Homeopathy	11	21	37	8	2
Herbal therapy	11	24	36	5	3
Reflexology	4	16	34	21	4
Aromatherapy	5	20	40	10	4

n: number

at healthcare settings due to the fear of the infection was the main issue ($n=60$, 75.9%). Increased admission of post-stroke patients with multimorbidities and multiple cardiometabolic risk factors ($n=38$, 48.1%), with severe depression ($n=28$, 35.4%), and with memory loss and communication difficulties ($n=20$, 25.3%) was also among the main issues.

Post-stroke telerehabilitation

A total of 26 (32.9%) participants agreed, and 10 (12.7%) participants strongly agreed that telerehabilitation is an effective means for a sizable number of post-stroke patients residing in remote areas and immobilized during the peri-pandemic period. Figure 6 shows the main barriers to implementing post-stroke telerehabilitation. The main barriers were listed as follows: lack of post-stroke patients' telecommunication skills ($n=58$, 73.4%), likelihood of errors with remote physical examinations and patient management ($n=48$, 60.8%), inaccessibility of high-speed Internet communication ($n=40$, 50.6%), and lack of specialists' telecommunication skills ($n=36$, 45.6%).

Countries were divided into two groups, Türkiye and others, and the acceptance of telerehabilitation for remote and immobile patients in post-stroke rehabilitation was compared. The total number of agree and strongly agree responses was 30 (51.7%) for participants from Türkiye and 9 (42.9%) for others ($p=0.023$).

Discussion

This study examined the knowledge and perceptions of healthcare professionals regarding post-stroke rehabilitation in the peri-pandemic period. The obtained results provide insights into several facets of post-stroke rehabilitation, including the use of complementary therapies and telerehabilitation.

Although the sample size was relatively small ($n=79$), more than four-fifths of the participants had more than five years of experience in the field. There were participants

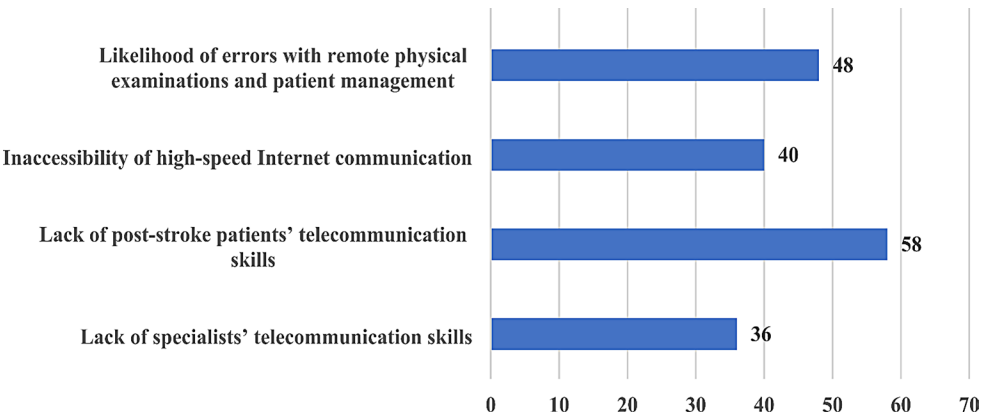

Fig. 6 The main barriers to the implementation of post-stroke telerehabilitation during the peri-pandemic period

from eight different countries. The prominent involvement of physiatrists, neurologists, and physiotherapists in stroke rehabilitation is an expected outcome.

Two-thirds of respondents were affiliated with specialized stroke rehabilitation clinics in urban areas. This scenario highlights the challenges that rural patients may encounter during post-stroke rehabilitation [24].

The main barriers to stroke rehabilitation were the lack of advanced rehabilitation techniques, trained healthcare professionals, and space. In stroke rehabilitation, clinics are enhanced with specialized approaches, backed by multidisciplinary components, and have adequate space, and health professionals provide beneficial outcomes [25].

More than half of the participants reported overseeing the care of more than five patients undergoing stroke rehabilitation per month. However, less than half were engaged in research reporting in the field of stroke rehabilitation. Stroke rehabilitation is an increasingly important scientific field [26, 27]. It is crucial for allied health professionals with an interest in this subject to stay updated and engage in research advancing rehabilitation strategies.

Diminished functional independence, immobility, and depression were the main clinical conditions targeted by the current survey participants during post-stroke rehabilitation. The survey participants viewed the concerted actions of patients, physiotherapists, physiatrists, and family members as a precondition of the efficiency of post-stroke rehabilitation. Reportedly, family- and patient-centered efforts enhance the effectiveness of rehabilitation initiatives [28].

The overwhelming majority of the survey participants agreed that stroke rehabilitation should be provided at specialized clinics with access to comprehensive multidisciplinary care, which is in line with previous reports of the advantages of multidisciplinary teams [29, 30].

Increasing physical activity was noted as the main tactic for reducing cardiovascular risk in the context of post-stroke rehabilitation. Compelling evidence suggests that physical activity post-stroke can enhance cardiovascular well-being, walking capacity, and muscular strength [31, 32].

The survey revealed that constraint-induced movement therapy and orthosis-prosthesis applications could be the most effective approaches. Transcranial current stimulation, transcranial magnetic stimulation, and robotic rehabilitation were the least employed rehabilitative modalities. The results suggest that traditional rehabilitation modalities are frequently employed while access to high-tech modalities is restricted. The survey participants endorsed music and dance therapy and massage as valuable complementary methods. Post-stroke patients and their rehabilitation specialists are positive toward complementary methods' mental and physical advantages [33]. Overall, safe and non-invasive traditional modalities are often favored by patients and health professionals [34].

The survey results confirmed that the COVID-19 pandemic negatively affected the process of post-stroke rehabilitation in healthcare facilities. The most prominent pandemic-related effect was decreased admission of patients to post-stroke rehabilitation at healthcare settings due to the fear of the infection. The quarantine measures, including social isolation, have posed challenges for patients seeking to access healthcare facilities. In the pandemic, hospital admissions decreased worldwide due to psychological causes, such as the fear of contracting infection [35].

Telerehabilitation has emerged as a promising approach to address the challenges posed by the pandemic [36]. Nearly half of the survey participants favored telerehabilitation in the pandemic. The main obstacles to telerehabilitation were lack of post-stroke patients' telecommunication skills and likelihood of errors with remote physical examinations and patient management. Various mechanisms might underlie these perspectives. Patients' compliance with telerehabilitation protocols may diminish due to reduced cognitive function. Moreover, physical examination and patient care via remote access may exhibit deficiencies compared to standardized assessments. Addressing these challenges could be particularly beneficial for improving rural patients' access to rehabilitation in the future.

Admitedly, a relatively small sample size is the main limitation of this survey. The predominance of data from Türkiye, Kazakhstan and Ukraine further limits the generalization of the data and related conclusion. Also, there was an imbalance in the participation of health professionals, with more than two-thirds being physiatrists with interest in stroke rehabilitation.

Conclusion

This survey results provide valuable insights into the knowledge and perspectives of healthcare professionals in the field of post-stroke rehabilitation during the peri-pandemic period. The survey participants emphsized the importance of complex rehabilitation measures, including those based on advanced modalities. The study also pointed to the significance of a multidisciplinary approach to post-stroke rehabilitation. Telerehabilitation was viewed as a promising strategy to overcome the access obstacles caused by the COVID-19 pandemic.

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Author contributions Conceptualization: Assylbek MI, Zimba O, Yessirkepov M. Methodology: Assylbek MI, Zimba O, Yessirkepov M. Data curation: Assylbek MI, Zimba O, Yessirkepov M, Kocyigit BF. Formal analysis: Assylbek MI, Zimba O, Yessirkepov M, Kocyigit. BF. Investigation: Assylbek MI, Zimba O, Yessirkepov M, Kocyigit BF. Visualization: Kocyigit BF. Writing - original draft: Assylbek MI, Zimba O, Yessirkepov M, Kocyigit BF. Writing - review & editing: Assylbek MI, Zimba O, Yessirkepov M, Kocyigit BF.

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Data availability Corresponding author can provide raw data upon reasonable request.

Declarations

Conflict of interest The authors declare no conflicts of interest.

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Original Article

The Impact of the Severe Consequences of a Stroke on Family Members Providing Care

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ABSTRACT

Background and rationale: Stroke radically changes the life not only of the patient but also of their relatives. Family members experience this event no less, and sometimes even more, than the patient themselves. Suddenly, they bear a huge additional burden: in the first weeks, they balance between household chores, work, and frequent hospital visits. After discharge, a complex process of caring for a bedridden patient begins. If the recovery of lost functions is prolonged, and aspects such as mobility, memory, speech, and self-care skills do not return, relatives accumulate chronic fatigue—both emotional and physical—as well as what is known as "caregiver fatigue." Like the patient themselves, the family member providing care experiences an overwhelming sense of anxiety, and sometimes they too lose hope of returning to the previous life, which now seems distant and carefree.

Keywords

stroke, relatives of stroke patients, care for stroke patients, quality of life, telerehabilitation, questionnaire.

INTRODUCTION

As part of this study, an anonymous survey was conducted among the close relatives of stroke patients. The goal was to better understand their quality of life and the challenges they face while caring for their loved ones at home. The survey was available in both Kazakh and Russian and was carried out among the families of patients undergoing rehabilitation at the "Mediker" medical center over the past year. Participants came from various regions of the Turkestan region, including Jetysai, Saryagash, Shardara, Turkestan, Sayram, and others. To ensure the accuracy and relevance of the responses, the questionnaire was carefully validated before being used in the study. The validation process included expert evaluation of

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the questionnaire's content to verify its alignment with the research questions and target audience. The expert group consisted of recognized specialists in neurology, psychiatry, rehabilitation, and neurosurgery, as well as international experts. After making the necessary adjustments, the questionnaire was tested on a small group of caregivers to assess its clarity and ease of completion. The questionnaire asks respondents to rate their quality of life on a scale from 1 to 116, where higher scores indicate better quality of life and lower scores indicate worse quality of life. The expected time required to complete the questionnaire is approximately 15 minutes. The questions are aimed at identifying the main difficulties faced by relatives of patients with severe stroke consequences. The questionnaire includes 10 questions with additional sub-items. The collected data were analyzed using statistical methods to identify key issues faced by caregivers and to assess their impact on quality of life.

RESULTS

Based on the analysis of responses from the relatives of patients who have suffered a stroke, several conclusions can be drawn, and specific measures can be proposed to improve the situation. Many caregivers experience significant psychological pressure, which adversely affects their emotional well-being. Relatives of patients who received continuous rehabilitation and utilized tele-rehabilitation demonstrated significantly better quality of life outcomes (χ^2= 64.0002, df=6, p=0.000000). The emotional and psychological state of respondents significantly differs ($p<0.005$) from those respondents who do not receive or rarely receive rehabilitation services (χ^2= 51.4600, df=6, p=0.000000). Data analysis from the survey using Kruskal-Wallis ANOVA by Ranks revealed that the total score of responses significantly varies ($p<0.005$) among groups formed by familial relationships (H (9, N=287) = 110.3189, $p<0.001$). Respondents noted a lack of highly qualified rehabilitation centers in the Turkestan region, forcing patients to seek care in larger rehabilitation facilities in the city of Shymkent. The study results underscore the need for psychological support and training in stress coping strategies, which has laid the groundwork for developing a program to enhance psychological assistance through tele-rehabilitation, planned for implementation on the website: https://rehabhome.kz.

MATERIALS AND METHODS

Stroke is one of the leading causes of disability and death worldwide, creating a significant burden not only for patients but also for their families. Family members who provide care often face physical, emotional, and financial challenges, which can adversely affect their quality of life [1].

The Importance of Social Support: The study "Social support as a predictor of rehabilitation outcome in stroke patients" emphasizes how emotional and practical support from family and friends can significantly influence rehabilitation outcomes after a stroke. The authors found that patients with high levels of social support demonstrate better results in physical recovery and psychological well-being. However, it is essential to expand training for caregivers while carefully developing new interventions and programs to avoid increasing the burden on those providing care[2]. The role of family in the rehabilitation process. The results of the study "Family involvement in stroke rehabilitation" confirm that active family participation in the rehabilitation process contributes to improved functional outcomes and overall quality of life for patients after a stroke. Researchers emphasize the need to educate families on caring for patients and providing them with appropriate resources and support [3]. Another study addresses the issues of accessibility and quality of rehabilitation services for stroke patients. Survivors of stroke and their caregivers identified the lack of information about stroke as a major barrier to accessing post-stroke rehabilitation services. Caregivers expressed a significant need for support in managing family dynamics [4]. Overcoming social isolation and stigma. The authors of the study "Overcoming social isolation and stigma after stroke" discuss the issues of social isolation and stigma faced by many stroke patients. The study highlights the importance of social initiatives and programs to facilitate the reintegration of patients into society, including public education campaigns and the development of support networks. Researchers argue that reducing stigma and social isolation contributes to improved psychological well-being and eases the recovery process, enhancing patients' confidence in their abilities and promoting their social engagement [5].

Socioeconomic aspects of recovery.

The study "Socioeconomic factors influencing post-stroke recovery" examines the impact of socioeconomic status on recovery outcomes after a stroke. The authors found that low socioeconomic status is associated with poorer recovery outcomes, including reduced access to quality rehabilitation services and medical care. It is recommended to enhance support from the government and community organizations to improve access to rehabilitation for individuals from less affluent backgrounds [6]. Technology and social support. The study "The role of technology in enhancing social support for stroke survivors" focuses on the development of digital technologies that create new opportunities for strengthening social support for stroke patients. The research explores how social networks, mobile applications, and tele-rehabilitation platforms can facilitate the social integration of patients by providing access to information, educational resources, and communication with peers. Such technologies can help overcome physical and geographical barriers, improving quality of life and accelerating the recovery process [7]. Social aspects of recovery after a stroke encompass a wide range of issues, from the accessibility of medical and rehabilitation services to social support and integration into society [8]. Scientific research emphasizes the need for a comprehensive approach to rehabilitation that considers both the medical and social needs of patients. Active family involvement, access to quality rehabilitation services, overcoming social stigma and isolation, as well as utilizing digital technologies to enhance social support are key factors for successful recovery after a stroke [9]. The disability experienced by stroke survivors, along with symptoms of depression, anxiety, and stress in both survivors and their family caregivers, affects their own quality of life and that of their partners. The disability of stroke survivors directly diminishes their overall, physical (PCS), and mental quality of life (MCS). Furthermore, it indirectly reduces both physical (PCS) and mental quality of life (MCS) for stroke survivors and their family caregivers through symptoms of depression, anxiety, and stress [10,11]. Formulating a testable working hypothesis is the first step toward conducting original research. Such studies can confirm or refute the proposed hypothesis. Case reports, case series, online surveys, and other observational studies, clinical trials, and narrative reviews help generate hypotheses. Observational and interventional studies assist in testing hypotheses. A good hypothesis is typically based on previous evidence-based reports. Hypotheses lacking evidence-based justification and a priori ideas are not favorably received by the scientific community. Original research to test a hypothesis must be meticulously planned to ensure appropriate methodology and adequate statistical power [12].

Psychological aspects of recovery after stroke represent a complex field that requires careful investigation. The main psychological challenges include coping with post-stroke depression, anxiety, stress, as well as issues of social isolation and loneliness, which cannot be overlooked. For a deep understanding of these aspects, it is important to refer to current scientific research and reviews. Studies show that depression occurs in 1 in 3 patients after a stroke. The importance of early diagnosis and treatment of depression is emphasized in works analyzing its impact on recovery after a stroke. They indicate that depression not only worsens of life for patients but can also negatively affect physical recovery [13]. Anxiety is also a common consequence of stroke, with research indicating a high comorbidity of anxiety disorders and depression post-stroke. Works such as the study by Campbell Burton et al. discuss the importance of considering anxiety in a comprehensive recovery plan, emphasizing that anxiety can significantly impact a patient's overall rehabilitation capacity [14]. Social isolation and feelings of loneliness can be exacerbated in the context of a pandemic, which in turn worsens psychological well-being and slows the recovery process. A study conducted by Valtorta and Hanratty demonstrates how social isolation affects the physical and mental health of older adults, which is particularly relevant for stroke patients, as age is one of the risk factors for stroke [15]. Research on psychological resilience during crisis situations, such as a pandemic, emphasizes the significance of adaptive coping strategies, such as seeking social support, positive reframing, and developing problem-solving skills. For instance, the work of Connor and Davidson presents a resilience assessment scale that can be useful for evaluating patients' ability to adapt to challenges related to their condition and external circumstances [16]. The role of social support cannot be underestimated. Studies demonstrate that quality social support contributes to improved psychological well-being and accelerates the recovery process. In the context of a pandemic, finding new ways to maintain connections and communication has become even more crucial. Research conducted

by Smith and Lim highlights the significant role of virtual social networks and technologies in sustaining social connectivity during the pandemic [17]. Reduced functional independence, immobility, and depression were the primary clinical conditions initially targeted by survey participants during rehabilitation after a stroke. Survey participants believed that collaborative efforts among patients, physiotherapists, rehabilitation specialists, and family members were essential for effective stroke rehabilitation. Reportedly, family- and patient-centered efforts enhance the effectiveness of rehabilitation initiatives [18].

The use of telemedicine in patient care.

Below are key strategies based on the latest scientific research in this area. Tele-rehabilitation includes video consultations with doctors, the use of mobile applications to track progress and perform exercises, as well as online sessions with therapists. The impact of telemedicine on the rehabilitation of stroke patients. Telemedicine is becoming an increasingly important tool in the rehabilitation of patients who have suffered a stroke. Research shows that tele-rehabilitation can significantly improve the quality of life for both patients and their relatives. Telemedicine provides unique opportunities for post-stroke rehabilitation, allowing patients to receive necessary assistance without leaving their homes. Tele-rehabilitation (TR) is less costly and equally effective as in-clinic rehabilitation in improving functional outcomes for stroke patients. TR ensures similar patient satisfaction. TR can be combined with other types of therapy, including virtual reality (VR), speech therapy, and robotic assistance, or used as an adjunct to direct in-person care [19]. A systematic review confirms that tele-rehabilitation can lead to improved functional outcomes and quality of life for stroke patients only if it is supported by a tele-education program for caregivers and ongoing technical, computer, and medical support to meet the needs of the dyad [20]. This is particularly important for relatives who often face challenges in caring for patients, and telemedicine can alleviate their burden by providing access to professional help and resources. The reverse learning method combined with video training enhances the caregiving skills of family members and can improve the self-care abilities of stroke survivors [21]. This is especially relevant considering that caring for stroke patients can be emotionally and physically exhausting. The authors note that telemedicine interventions have demonstrated significant effectiveness in managing chronic diseases. The implementation of tele-rehabilitation not only improves access to medical care but also promotes the individualization of rehabilitation programs, which, in turn, can lead to more effective treatment outcomes [22]. Additionally, research shows that telemedicine can improve access to specialized care. The use of telemedicine in the care of stroke patients helps overcome geographical barriers and provides broader access to rehabilitation services [23]. This can be particularly beneficial for families living in remote or rural areas. The integration of telemedicine technologies into the rehabilitation process can significantly enhance the quality of life for both patients and their families [24]. The use of remote access and telemedicine services, which played a crucial role during the pandemic, is expected to gain even greater importance in the coming years. Furthermore, artificial intelligence technologies hold significant potential in revolutionizing the delivery and individualization of rehabilitation according to the needs of each patient [25]. Medical professionals and researchers should collaborate with caregivers of stroke patients to identify their valuable activities and implement realistic strategies to maintain these activities [26]. The results of another study indicate that depression affects the quality of life of both stroke survivors and their caregivers, not only emotionally but also physically [27]. A multidisciplinary approach to post-stroke rehabilitation, including the use of modern modalities, plays a crucial role in conducting comprehensive rehabilitation activities [28].

This survey was developed based on relevant reviews and practical recommendations. Relevant survey reports were studied to create the questionnaire. The survey protocol was reviewed and approved by the Local Ethics Committee of the Medical Academy of South Kazakhstan in Shymkent, Kazakhstan (protocol No. 3 dated June 5, 2024). Written informed consent was obtained from all voluntary participants at the beginning of the questionnaire. No compensation for participation in the survey was offered. All questions were mandatory. The survey was completely anonymous, and only completed forms were processed. Convenience sampling was used in this report, adhering to widely published guidelines for survey design and reporting.

Brief Description of the Structure and Content of the Questionnaire:

1. Identification and Relationship:
2. The survey begins with questions about the relationship of the relatives to the patient and their age.
3. Daily Challenges: Questions address the problems relatives face daily, such as tracheostomy care, diaper changes, and feeding, with response options ranging from "Always" to "Never".
4. Emotional and Physical Discomfort: This section touches on emotional, physical, and practical difficulties in providing care, with response options from "Definitely true" to "Definitely not true."
5. Adherence to medical recommendations: Relatives are asked about difficulties with medication dosages, names, and adherence to the diet prescribed by the doctor.
6. Household and Financial Issues: Questions explore logistical and financial difficulties in the home environment, such as lack of space for wheelchair movement and financial problems due to the patient's illness.
7. Access to Rehabilitation Services: The questionnaire assesses the availability of rehabilitation centers and the presence of medical consultations.
8. Awareness and Participation in Rehabilitation: The knowledge and involvement of the relative in the rehabilitation process are checked.

Statistical Analysis: Descriptive statistics are presented in both absolute numbers and percentages. Microsoft Excel was used to create the database of responses and for their coding. The Kruskal-Wallis ANOVA by Ranks test was applied to compare responses between groups. Since the groups did not have a normal distribution, the surveyed relatives were divided into several categories (father, mother, husband, wife, brother, sister, daughter-in-law, son-in-law, son, daughter), and the table of critical values for the χ^2 test was used, as the Kruskal-Wallis test asymptotically approaches the χ^2 distribution. Results were considered statistically significant at a significance level of P less than 0.05. Statistical analysis was conducted using Microsoft Excel and Statistiks. Table 1 presents data on relatives caring for patients after a stroke. A total of 340 relatives were surveyed, of which 52 were excluded from the analysis (for reasons such as poor-quality responses, repeated refusals, etc.). The final analysis included 287 respondents aged 18 to 67 years.

Table 1. Distribution of Relatives by Gender and Age

n	287	age	Men/ women
Mother	20	49-67	20
Father	13	47-61	63
Wife	38	42-66	38
Husband	31	43-64	31
Son	63	22-53	63
Daugther	57	18-42	57
Son-in-law	3	29-52	3
Daugther-in-law	11	28-44	11
Brother	27	28-44	27
Sister	24	33-49	24

To analyze the impact of the type of family relationship on the qualitative indicators of caregiving skills for a sick relative, the non-parametric Kruskal-Wallis test was applied. The test results (H (9, N=287) = 110.3189, p <0.001) indicated statistically significant differences between groups. The most common caregiving difficulties and emotional discomfort were reported by «Wives» (H (9, N=20) = 171.2), « Brothers» (H (9, N=26) = 103.2), and «Sons» (H (9, N=63) = 113.81), as well as «Sisters» (H (9, N=20) = 26.3) and «Daughters-in-law» (H (9, N=43) = 171.2). «Daughters» (H (9, N=57) = 213.4), «Fathers» (H (9, N=23) = 177.2), «Husbands» (H (9, N=31) = 155.2), and «Mothers» (H (9, N=20) = 175.2) reported satisfactory emotional states and noted that they cope better with caregiving challenges. For clarity, the results are presented in Figure 1.

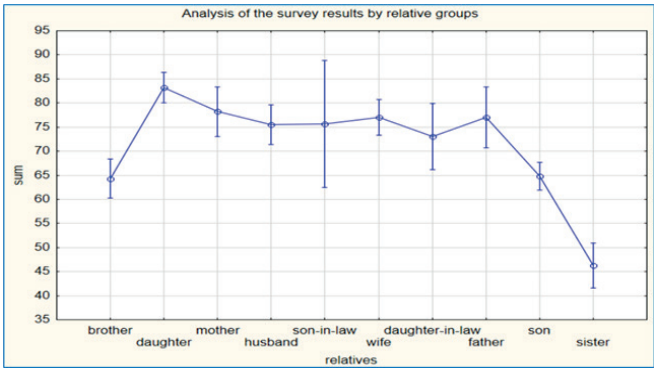

Fig. 1 This may suggest that many caregivers experience stress and dissatisfaction during the caregiving process. «Difficulties in Feeding Relatives» 33.5% of respondents

noted that they "Sometimes" face difficulties in feeding, while 16.7% reported that this happens "Always". This may indicate a need for training and support to improve feeding skills. «Psychological Difficulties» 36.9% of respondents reported that they "Sometimes" experience psychological difficulties while caring for the sick and 11.5% stated that this occurs "Always". This underscores the importance of psychological support for caregivers to help them cope with emotional burdens.

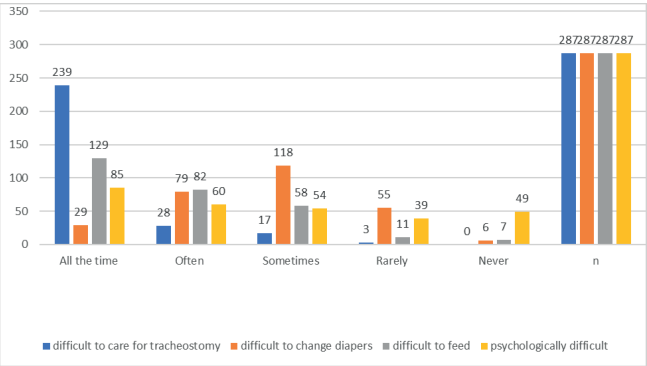

Figure 2 – Difficulties Faced by Caregivers of Sick Relatives

Figure 3 illustrates the distribution of the "Quality of Life" indicator, depending on the frequency of rehabilitation methods used and rehabilitation skills. As seen from Figure 1, the median "Quality of Life" varies based on the skills in using rehabilitation methods. The lowest level of "Quality of Life" is observed among relatives who rarely use rehabilitation methods (I know, but don't use = n-32 = 55). Relatives who regularly use rehabilitation methods («I use regularly» n-89=82) demonstrate the highest level of "Quality of Life." The median stress level in the groups («Rarely used» = n-76 = 58) and («We use it sometimes»= n-90 = 76) lies between these two extremes. There are also relatives of patients who hardly visit rehabilitation centers but utilize tele-rehabilitation, resulting in good quality of life (see description) (Pearson Chi-square: $\chi^2 = 64.0002$, df = 6, p = 0.000000).

Table 2. Respondents Agreement Levels on Various Aspects Related to Accessibility of Rehabilitation Centers and Physician Oversight. The table presents information on the level of agreement among respondents regarding various aspects related to the accessibility of rehabilitation centers and oversight by treating physicians. Respondents rated how often they

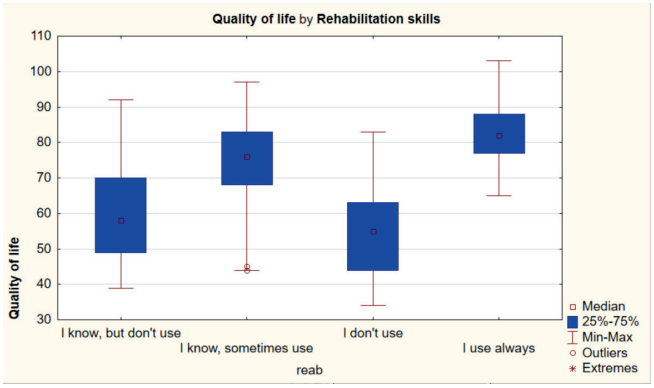

Figure 3. Distribution of Quality of Life Indicators Based on Rehabilitation Skills

utilize the specified resources, with possible response options: - "I do not use this" n-93 (32.4%), "I

rarely use this" n-76 (26.5%), "I use this sometimes" n-96 (33.5%), "I use this regularly" n-22 (7.7%). The data indicate that most respondents have some level of utilization of rehabilitation resources. However, a significant number of respondents also do not use them or do so rarely. This may suggest a need to raise awareness about the available rehabilitation services and their importance.

Table 2. Knowledge and application of rehabilitation among relatives of respondents

Level of agreement	I don't use it (n)	I rarely use it (n)	I use sometime (n)	I use it regularly (n)
Availability of a rehab center in our region	93 (32,4%)	76 (26,5%)	96 (33,5%)	22 (7,7%)
Observation by the attending physician	57(19,9%)	70 (24,4%)	101 (35,2%)	59 (20,6%
Knowledge about rehabilitation activities, us of TR	32 (11,1%)	76 (26,5%)	90 (31,4%)	89(31,0%

To assess the housing and living difficulties faced by caregivers of sick relatives, an analytical visualization was created based on the proposed categories. Each column displays the number of responses across four categories – from "Definitely true" to "Definitely

not true." This allows for an understanding of which living conditions are most problematic for caregivers. For instance, most caregivers indicated that their relatives often stay home alone while everyone is at work, which poses a significant challenge. Figure 4 illustrates various aspects of discomfort experienced by caregivers of sick relatives. Different colors of the columns reflect the degree of agreement among caregivers with each statement – from "Definitely true" to "Definitely not true." This visually highlights which aspects of caregiving cause the greatest difficulties and discomfort.

Table 4

Level of agreement	Definitely true (n)	Mostly true (n)	Mostly not true (n)	Definitely not true (n)
Psychologically discomfort	189(66%)	52(18%)	35(12%)	11(4%)
Physical discomfort	36(13%)	85(30%)	115(40%)	51(18%)
Uncertainty about help	35(12%)	90(31%)	93(32%)	69(24%)
Discomfort due to gender	35(12%)	90(31%)	122(42%)	42(15%)

The responses from the participants indicate that the most significant issue for them is psychological discomfort, with 66% responding "Definitely true." In contrast, physical discomfort is distributed more evenly. Uncertainty regarding assistance and discomfort related to gender show a more varied distribution of responses, suggesting less consensus on these issues. The results highlight the need for further investigation into the causes and consequences of each type of discomfort.

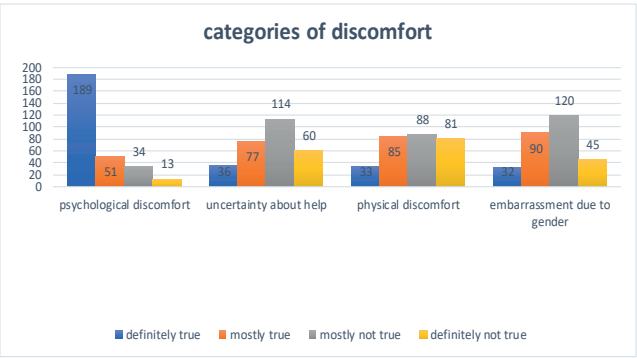

Figure 4 – Discomfort of Caregivers for Sick Relatives

To evaluate the living conditions and challenges faced by caregivers of sick relatives, an analytical visualization was created based on the proposed categories. Table 4 presents the living difficulties encountered by caregivers. Each column displays the number of responses across four categories – from "Definitely true" to "Definitely not true". This allows for the identification of the most problematic living conditions for caregivers. For instance, the majority of caregivers indicated that their relatives often stay home alone while everyone is at work, which poses a significant challenge. Table 5 presents the survey results in which respondents assessed their level of agreement with various statements regarding living conditions and support for sick relatives. Each respondent selected one of four options: "Definitely true," "Mostly true," "Mostly not true," and "Definitely not true". The data indicates that respondents largely agree with statements regarding the challenging living conditions and support for sick relatives. The most pronounced agreement is observed for the statement "there is no one to care for the sick relative," with 54% of respondents agreeing with this assertion. A significant number of respondents also point to financial constraints and limited space for wheelchair access. These findings underscore the importance of improving living conditions and support for families caring for the sick.

Table 5. Housing difficulties among respondents

Level of agreement	Definitely true (n)	Mostly true (n)	Mostly not true (n)	Definitely not true (n)
The toilet is located outside	39(18.5%)	79(37.5%)	98(46.7%)	70(33.3%)
The sick relative was the only breadwinner in the family	27(12.8%)	88(42.0%)	102(48.8%)	69(32.5%)
Cramped accommodation for wheelchair	36(17.0%)	78(36.5%)	101(47.0%)	72(33.3%)
Financial limitation	26(12.3%)	85(40.7%)	107(51.2%)	69(32.5%)
No one to care for a sick relative	27(12.8%)	87(42.0%)	113(54.0%)	60(28.3%)

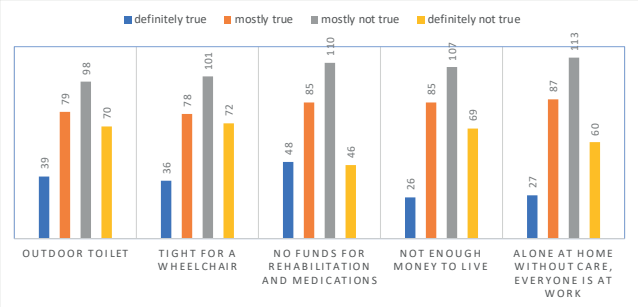

Figure 5 – Housing and living difficulties faced by caregivers of relatives.

The data indicates that the majority of respondents experience various conditions such as apathy, neurotic changes, and feelings of malaise with noticeable frequency. The most pronounced symptoms, such as fatigue and frustration, show high rates of "Always" and "Often." Meanwhile, feelings of loneliness and sleep disturbances also raise significant concern, with a notable number of respondents reporting that they "never" experience these states.This data may be useful for further analysis of the mental and physical health of respondents and the development of appropriate interventions.

Table 6. Emotional and mental state of respondents

Level of agreement	All the time (n)	Ofthen (n)	Sometimes (n)	Rarely (n)	Never (n)
Apathy	24(8,0%)	61(20,3%)	102(34,3%)	92(30,7%)	8(2,7%)
Neurotic change	26(8,7%)	65(21,7%)	89(29,7%)	98(32,7%)	9(3,0%)
Feeling unwell	59(19,7%)	61(20,3%)	93(31,0%)	57(19,0%)	17(5,7%)
Fatigue	72(24,0%)	71(23,7%)	73(24,3%)	56(18,7%)	15(5,0%)
Disouraged	79(26,3%)	54(18,0%)	86(28,7%)	52(17,3%)	16(5,3%)
Loneliness	26(8,7%)	59(19,7%)	64(21,3%)	49(16,3%)	89(29,7%)
Sleep disorder	41(13,7%)	89(29,7%)	97(32,3%)	51(17,0%)	9(3,0%)
Deterioration of health	64(21,3%)	62(20,7%)	88(29,3%)	49(16,3%)	24(8,0%)

Each respondent indicated how often they experience the specified conditions by selecting one of five options: "Always", "Often", "Sometimes", "Rarely" and "Never". The main categories and their values are as follows: Apathy: n-24 (8.0%) reported feeling apathetic "Always" n-61 (20.3%) "Often" n-102 (34.3%) "Sometimes" n-92 (30.7%) "Rarely" and n-8 (2.7%) "Never" Neurotic changes: n-26 (8.7%) "Always," n-65 (21.7%) "Often," n-89 (29.7%) "Sometimes" n-98 (32.7%) "Rarely" and n-9 (3.0%) "Never". Sleep disturbances: n-41 (13.7%) "Always," n-89 (29.7%) "Often" n-97 (32.3%) "Sometimes" n-51 (17.0%) "Rarely" and n-9 (3.0%) "Never". Health deterioration: n-64 (21.3%) "Always" n-62 (20.7%) "Often" n-88 (29.3%) "Sometimes" n-49 (16.3%) "Rarely" and n-24 (8.0%) "Never" (Table 6).

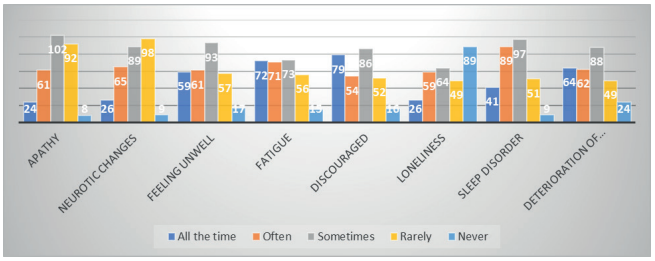

Figure 6 – Emotional State of Respondents

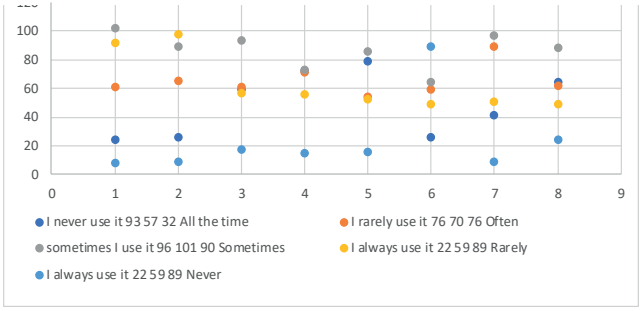

Fig.7 – Dependence of 2 variables -Emotional state of respondents and application of regular rehabilitation

The graph illustrates the relationship between various emotional states (such as apathy, neurotic changes, feelings of malaise, fatigue, despondency, loneliness, sleep disturbances, and health deterioration) and the frequency of rehabilitation visits. The horizontal axis represents different emotional states, while the vertical axis indicates the number of respondents. «Feeling unwell»: n-59 (19.7%) - "Always", n-61 (20.3%) "Often", n-93 (31.0%) "Sometimes", n-57 (19.0%) -"Rarely", n-17 (5.7%) "Never". «Fatigue»: n-72 (24.0%) - "Always", n-71 (23.7%) - "Often", n-73 (24.3%) - "Sometimes", n-56 (18.7%) - "Rarely", n-15 (5.0%) - "Never". «Discouraged»: n-79 (26.3%)

- “Always”, n-54 (18.0%) - “Often”, n-86 (28.7%) - “Sometimes”, n-52 (17.3%) - “Rarely”, n-16 (5.3%) - “Never”. «Loneliness»: n-26 (8.7%) - “Always”, n-59 (19.7%) - “Often”, n-64 (21.3%) - “Sometimes”, n-49 (16.3%) - “Rarely”, n-89 (29.7%) - “Never”. Each column for each emotional state is divided into four colored sections representing the frequency of experiencing that state. Although the graph itself does not show a direct correlation between emotional state and attendance at rehabilitation, it provides a basis for such analysis (Figure 7). It can be suggested that more frequent negative emotional states may be associated with more frequent attendance at rehabilitation activities. An analysis was conducted between two variables: those who regularly attended rehabilitation centers and those who did not. It was found that the quality of life for relatives of patients who regularly attend rehabilitation centers is better than for those who have little contact with medical personnel and who receive rehabilitation

less frequently or never. Pearson Chi-square -χ^2=51.4600, df=6, p=0.000000 (see description).

RESULTS

The study involved relatives of patients who had suffered a stroke, with a total of n=287 respondents and an average age of 38 years (ranging from 18 to 67 years), including 145 women and 142 men. Many relatives experience significant psychological pressure related to caregiving, which negatively impacts their emotional well-being. Based on the analysis of responses from relatives of stroke patients, several key conclusions can be drawn, along with specific recommendations for improving the situation. Many caregivers face considerable psychological stress, which negatively impacts their emotional well-being. Relatives of patients who engaged in continuous rehabilitation and utilized tele-rehabilitation reported significantly better quality of life outcomes (χ^2= 64.0002, df=6, p=0.000000). The emotional and psychological states of respondents were found to differ significantly ($p<0.005$) from those who do not receive or infrequently access rehabilitation services (χ^2= 51.4600, df=6, p=0.000000). Analysis of survey data using Kruskal-Wallis ANOVA by Ranks indicated that the overall response scores varied significantly ($p<0.005$) among groups categorized by familial relationships (H (9, N=287) = 110.3189, $p<0.001$). Respondents highlighted a shortage of highly qualified rehabilitation centers in the Turkestan region, compelling patients to seek care in larger rehabilitation facilities located in the city of Shymkent.

Psychological support and training in stress coping strategies are necessary. A lack of knowledge about proper caregiving, including medication management and dietary adherence, often leads to mistakes and increases the stress of relatives. This issue highlights the need for more accessible and effective educational programs. Access to rehabilitation and medical services is limited, especially in underprivileged or remote areas. The situation requires improvements in infrastructure and the implementation of innovative solutions, such as telemedicine. Continuous caregiving exceeds the physical and emotional capacities of many relatives, emphasizing the need for additional support and home care services.

DISCUSSION

To support families caring for stroke patients, it is essential to implement targeted psychological support programs and self-help groups, helping relatives navigate both the emotional and practical challenges of caregiving. Providing accessible educational resources on medical care, medication management, and dietary adherence can empower caregivers with the knowledge they need. Regular training sessions and seminars led by medical professionals can further enhance their skills and confidence. Expanding rehabilitation services by increasing mobile clinics and integrating telemedicine for remote consultations can make care more accessible. Additionally, offering home care services—including professional caregiving and assistance with daily tasks—can help ease the burden on families. These recommendations can contribute to the development of policies and programs that improve the quality of life for both stroke patients and their caregivers, ensuring a well-rounded and effective approach to post-stroke care.

Authors Contributions

Conceptualization: KBF, AMI, YM. Data acquisition and literature review: KBF, AMI, YM. Interpretation: KBF, AMI, YM. Writing — review and editing: KBF, AMI, YM. Final approval: KBF, AMI, YM.

Funding: None

Data Availability: Appendix on questionnaire validation

Conflict of Interest: The authors declare no conflicts of interest.

DESCRIPTION

Interview Methodology

To gain a deeper understanding of the personal experiences of patients and healthcare providers, the study employed both individual and focus group interviews. These qualitative research methods are particularly valuable for exploring complex issues, such as the impact of the pandemic on daily life and well-being. Individual interviews were conducted in a quiet, confidential setting, allowing participants to freely express their thoughts and feelings. The interviewer utilized a semi-structured approach, posing open-ended questions that enabled participants to share their experiences, emotions, and opinions without strict limitations. Focus group interviews gathered several participants (typically 4-8 individuals) to discuss specific topics. This method facilitated interaction among participants, which could lead to the emergence of new ideas and insights that may not always be attainable in individual interviews. Focus groups were organized to promote open and honest dialogue, taking into account group dynamics and ensuring that each participant had the opportunity to voice their perspectives.

Adaptation to Pandemic Conditions:

In light of social distancing measures, many interviews were conducted via video conferencing. This ensured the safety of both participants and interviewers while also allowing the inclusion of individuals who might not have been able to attend in-person meetings due to geographical or health-related constraints.

Data Assessment Methods for Interviews

The data collected through interviews necessitates careful analysis and interpretation:

1. **Transcription:** All audio and video recordings of the interviews were transcribed for subsequent textual analysis.
2. **Coding:** The interview texts were coded to identify key themes and categories. This process could be inductive (data-driven) or deductive (based on pre-defined categories).
3. **Thematic Analysis:** Thematic analysis was employed to identify recurring themes and patterns within the data. This approach allowed for the summarization of data and the identification of both explicit and implicit aspects of the pandemic's impact.
4. **Validity Checks:** The credibility and reliability of the findings were assessed through processes such as triangulation (utilizing different methods or data sources) and participant feedback.

This comprehensive approach to data collection and analysis from interviews aids in deeply understanding the personal experiences of participants, enriching quantitative survey data with qualitative details and in-depth insights.

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OBSERVATIONAL RESEARCH

YouTube as a source of information for stroke rehabilitation: a cross-sectional analysis of quality and reliability of videos

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Abstract

Introduction Due to YouTube's meteoric rise in popularity, the quality and reliability of health-related videos on YouTube are being questioned, particularly in specialized fields like stroke rehabilitation. This research aimed to assess the quality and reliability of YouTube videos relevant to stroke rehabilitation.

Method Video listing was conducted on December 17, 2024, using the keywords "Stroke Rehabilitation", "Stroke Physical Therapy", "Stroke Neurophysiotherapy", and "Stroke Physical Therapy Techniques" as query terms. A final sample of 72 videos was selected upon completion and evaluated according to inclusion and exclusion criteria. The Global Quality Scale (GQS), Modified DISCERN Questionnaire, JAMA Benchmark Criteria, and Patient Education Materials Assessment Tool for Audio/Visual Materials (PEMAT-A/V) were among the evaluation tools used to analyze each video. Researchers captured the videos' fundamental components and compared the quality classifications.

Results Of the 72 videos examined, 29.2% ($n=21$) were categorized as low quality, 20.8% ($n=15$) as intermediate level, and 50% ($n=36$) as high quality. Videos generated by academic medical centers (77.8%) and nonphysician healthcare professionals (59.4%) were primarily of high quality, while videos from independent users (100%) and TV channels (66.7%) displayed the lowest quality. Significant differences were observed when comparing quality groups based on daily views, likes, and comments ($p<0.05$). The lowest scores were detected in the low-quality group. Significant correlations were identified between GQS and other evaluative instruments ($p<0.001$), indicating consistency across evaluation frameworks.

Conclusion YouTube possesses considerable potential as an instructional tool for stroke rehabilitation. The inconsistency in video quality underscores the necessity for enhanced content control, editing, and the advocacy of high-quality, evidence-based resources. Promoting collaboration among academics, healthcare professionals, and content producers could augment the platform's instructional efficacy.

Keywords Stroke rehabilitation · Neurological rehabilitation · Social media · Internet · Information science

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Introduction

The internet has revolutionized access to health-related information, serving as a crucial resource for patients, carers, and medical professionals [1]. As digital devices become more prevalent and internet access expands, individuals turn to online platforms for information regarding medical issues, treatment alternatives, and rehabilitation approaches [2]. This trend represents a change towards patient empowerment, in which people actively participate in understanding their health and discovering ways to improve their well-being. The internet's ease of use and variety of materials make it the favored platform for individuals searching for health-related information [3, 4].

YouTube has become a favored source of health-related information among the numerous available platforms. YouTube provides a fascinating and accessible platform for disseminating information, hosting millions of videos covering various subjects. The platform's visual and audio aspects allow consumers to comprehend complicated healthcare subjects that would otherwise be challenging to understand solely through text [5, 6]. YouTube has a variety of health-related videos, including expert seminars, patient experiences, and educational guides, offering a distinctive chance to enhance health literacy. However, the uncontrolled nature of YouTube and the lack of editing support prompt concerns over the quality and accuracy of the information presented [7].

Stroke rehabilitation is an essential stage in the recovery process for individuals who suffered a stroke. This procedure employs a multidisciplinary strategy to restore the physical, mental, and emotional capacities affected by the incident [8]. In stroke rehabilitation, supporting sources, including instructional videos and audio recordings, are essential for improving adherence to physical therapy and facilitating comprehension [9]. Visual material can potentially instruct carers on safe practices, guide patients through appropriate movement approaches, and offer motivational tools to sustain participation in the rehabilitation course [10]. Therefore, stroke survivors can benefit substantially from YouTube and similar platforms, which provide readily available and user-friendly information to supplement conventional rehabilitation methods [11].

Emerging evidence points to a complicated connection between rheumatic disorders and cerebrovascular health. Chronic systemic inflammation, endothelial dysfunction, and immunity-related vascular damage in rheumatic diseases may raise the risk of stroke and impact post-stroke healing pathways. Given these concerns, rehabilitation procedures for stroke patients with underlying rheumatic disorders necessitate a more individualized approach that takes into account disease-related restrictions, fatigue, and potential drug interactions [12, 13].

This research evaluates stroke rehabilitation videos on YouTube. The first aim is to identify sources to reach high-quality videos by analyzing their features. Additionally, we aim to draw illuminating findings by comparing video parameters across quality categories. Lastly, it seeks to shed light on how effectively YouTube disseminates information about stroke rehabilitation.

Methods

The video inspection was held on December 17, 2024, with the keywords "Stroke Rehabilitation", "Stroke Physical Therapy", "Stroke Neurophysiotherapy" and "Stroke Physical Therapy Techniques" as query terms. The MeSH terms were used to determine the search phrases. Because YouTube places a premium on providing users with tailored results, all cookies and history were erased. The goal was to lessen the impact of past internet use. Before conducting the search, the Google Chrome browser was set to incognito mode to ensure anonymity for users. The listing was created using the default setting of "relevance-based ranking," which mirrors the routine actions of the typical platform user [14, 15]. A typical internet user accesses only a restricted segment of the listing. This has been substantiated by previous research. Therefore, the initial 50 videos for each search term were used in the assessment [16, 17]. The exclusion parameters were defined as follows: (1) videos in languages other than English, (2) repeated videos, (3) irrelevant videos, (4) videos shorter than 1 min or more than 60 min, and (5) videos having auditory or image defects. Videos under 1 min were excluded because they lacked complexity and thoroughness for providing valuable educational material, especially with the elaborate healthcare process of stroke rehabilitation. These concise videos may prioritize swift summaries, marketing materials, or incomplete interpretations that do not achieve the goal of thorough information dissemination. In contrast, videos over 60 min were removed to align with YouTube's typical user engagement patterns and ensure practical application. Online viewers, particularly those searching for medical information, tend to disengage from excessively long videos, finding them overwhelming, monotonous, or challenging to follow. In stroke rehabilitation, where patients and carers need clear, brief, and practical content, lengthy videos may cause cognitive overload and decreased retention of essential details. By establishing this criteria, we targeted videos more likely to be thoroughly viewed, retained, and realistically implemented by the intended audience.

The first step of the video assessment process was for two researchers to score the videos separately. Discrepancies were detected by comparing the independent ratings. Regarding the videos that had distinctions, a third researcher ultimately concluded. The agreement between scores was documented using Cohen's kappa coefficient [18].

Video parameters

The subsequent fundamental parameters were acquired via YouTube:

- Count of views, likes, and comments.
- Duration of the video (seconds).
- Interval between video upload date and listing date (days).
- Daily metrics of views, likes, and comments.

Based on the method of formatting, the videos were divided into four groups: (1) those with sole narrators, (2) those with a focus on the experiences of patients, (3) those with animations, and (4) those with slides to present.

Sources

Video sources were classified into the following categories:

- Physician.
- Nonphysician health care professional.
- Academic medical centers.
- Nonacademic healthcare facilities.
- TV channels.
- Nonprofit charities or foundations.
- Independent user.

Content evaluation

The Global Quality Scale (GQS), an established method for evaluating the usefulness and efficacy of educational resources found online, was implemented to measure the quality. Parts one through five make up the GQS. The potential scores are from 1 (very low) to 5 (very high). Inconsistency and significant gaps in the data are indicated by a score of 1. A score of 5 indicates a high level of consistency, which is highly beneficial. From 4 to 5 for high-quality videos to 3 for intermediate quality, videos rated 1 or 2 are considered low Quality [19, 20].

Researchers used the modified DISCERN instrument to measure reliability. Clarity, intelligibility, bias, objectivity, and the inclusion of references and supplemental resources are among the multiple criteria that this tool checks. Using dichotomous queries, this approach provides one point to positive responses and zero to failed responses. The most outstanding score that can be achieved is 5 [21].

The JAMA Benchmark Criteria serve as a framework for evaluating the accuracy and quality of online health data. These criteria assess fundamental elements that ensure the reliability of internet-based items, including ownership, authentication, disclosure, and currency [16].

Visual and auditory medical educational sources can be systematically evaluated regarding their understandability and actionability by employing the Patient Education Materials Assessment Tool for Audio/Visual Materials (PEMAT-A/V). By focussing on factors like organizational structure, terminology, clarity, and imagery, understandability evaluates how easily individuals may absorb knowledge. Actionability assesses whether the sources of information clearly outline tasks that patients can undertake to address the issue at hand. The percentage serves to denote the scores [22].

Statistical analysis

The Statistical Package for the Social Sciences (SPSS) software, version 29.0 (SPSS Inc., Chicago, IL, USA), was implemented for statistical analysis. The normality of the data distribution was checked using the Shapiro-Wilk test before the analyses. Medians, frequencies (n), and percentages (%) were utilized to express the results. The dataset was sorted into three quality categories, and the Kruskal-Wallis test was used to compare them. Researchers used Spearman's rho test for correlation analyses. Also, to find out the degree of agreement, researchers relied on the Kappa coefficient. For statistical significance, a p-value below 0.05 was considered adequate.

Results

A list of the most relevant 50 videos for each search phrase was compiled. For this analysis, 200 published videos were assessed; nevertheless, 128 were disqualified according to the criteria, allowing 72 videos to be considered. More information regarding the sample procedure is presented in Fig. 1. The median duration of the videos was 438.50 (61–3081) seconds. The median number of views, likes, and comments were 97,242 (51–1905604), 1200 (0–20000), and 64.50 (0–414), respectively. Among the videos, 80.6% ($n=58$) were presented with narrators only, 6.9% ($n=5$) with patient experiences, 4.2% ($n=3$) with animations and 8.3% ($n=6$) with slide presentations. The primary features of the videos are outlined in Table 1.

Based on the GQS rankings, the videos were split into three categories: low, intermediate, and high quality. Out of the total number of videos, 29.2% ($n=21$) were deemed

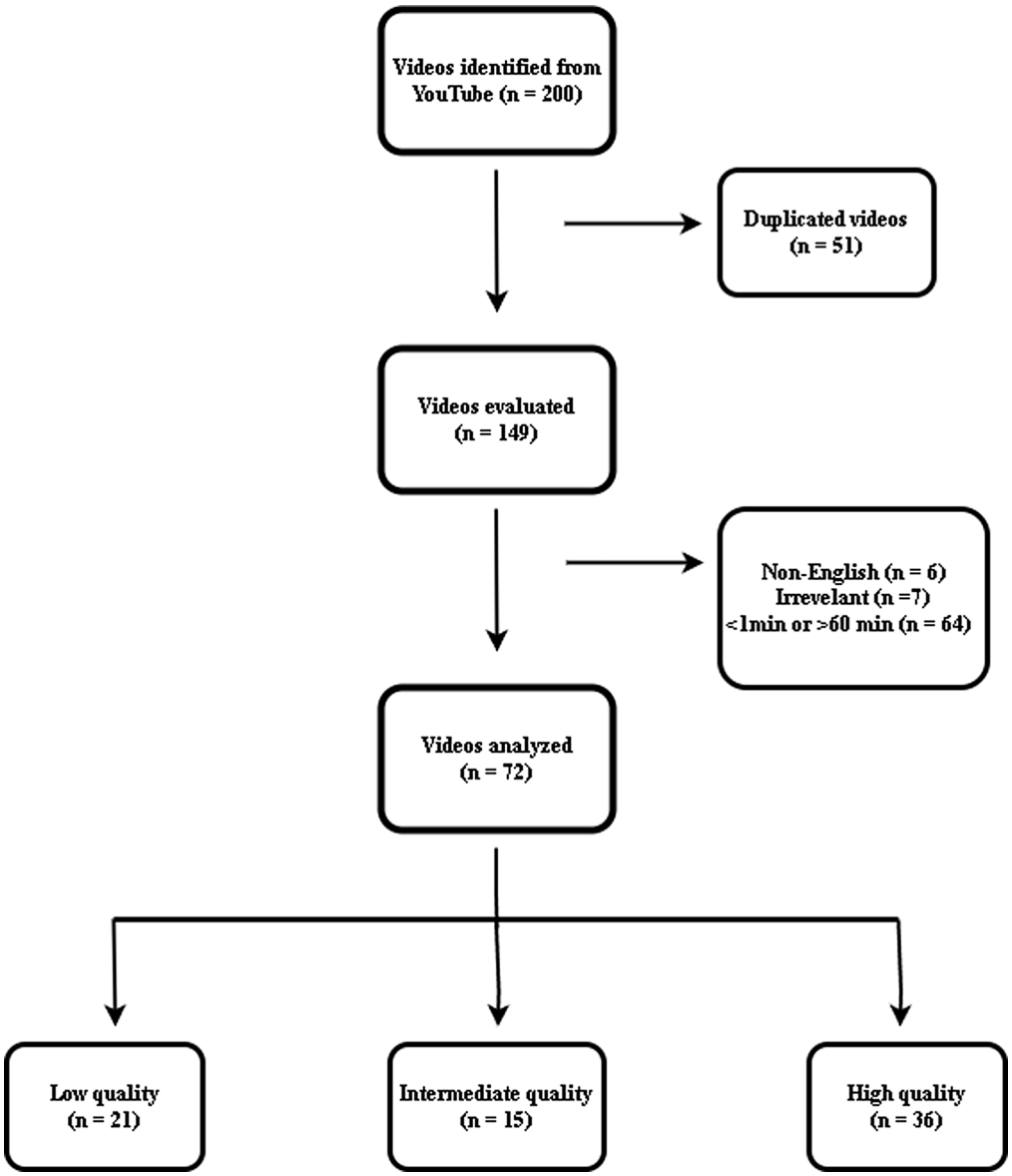

Fig. 1 Visualization of the inclusion and exclusion process of videos

Table 1 Primary features of the videos

Video features	
Duration (seconds)*	438.50 (61–3081)
Number of views*	97,242 (51–1905604)
Number of likes*	1200 (0–20000)
Number of comments*	64.50 (0 - 414)
Days since upload*	1709 (27 - 4978)
Views per day*	66.4 (0.1– 477.8)
Likes per day*	0.9 (0– 7.2)
Comments per day*	0.1 (0– 0.5)
Presentation method (n; %)	
Video containing only narrator(s)	58 (80.6)
Video containing patient experiences	5 (6.9)
Animation	3 (4.2)
Narrating with a slide presentation	6 (8.3)

* Data are expressed as median (minimum-maximum)

low quality, 20.8% ($n=15$) were deemed intermediate, and 50% ($n=36$) were deemed high quality. Video sources were categorized based on their quality. Academic medical centers and nonphysician health care professionals make up the bulk of the sources that supply high-quality videos (77.8% and 59.4%, respectively). However, according to Table 2, the sources that provided the lowest quality videos were independent users (100%) and TV channels (66.7%).

Significant differences were observed when comparing quality groups based on daily views, likes, and comments ($p<0.05$). The lowest scores were detected in the low-quality group (Table 3).

Correlation analyses were conducted between GQS and other video assessment tools, revealing statistically

Table 2 Categorization of the videos according to sources, N (%)

Source	Low quality	Intermediate quality	High quality	Total
Physician	0 (0)	0 (0)	0 (0)	0
Nonphysician health care professional	8 (25)	5 (15.6)	19 (59.4)	32
Academic medical centers	0 (0)	2 (22.2)	7 (77.8)	9
Nonacademic health care facilities	6 (37.5)	4 (25)	6 (37.5)	16
TV channels	2 (66.7)	1 (33.3)	0	3
Nonprofit charities or foundations	2 (22.2)	3 (33.3)	4 (44.5)	9
Independent user	3 (100)	0 (0)	0 (0)	3

n: number, %: percentage

significant correlations ($p<0.001$ for all and rho = 0.859 for Modified DISCERN Questionnaire, rho = 0.833 for JAMA Benchmark Criteria, rho = 0.816 for PEMAT-A/V Understandability and rho = 0.844 for PEMAT-A/V Actionability). In addition, researchers analyzed the correlations between the video parameters and the ratings on the video evaluation tools. Results showed positive correlations between the video duration and ratings on the GQS, Modified DISCERN Questionnaire, JAMA Benchmark Criteria, PEMAT-A/V Understandability, and PEMAT-A/V Actionability ($p<0.001$). Views per day and likes per day data were significantly and positively correlated with video evaluation tools ($p<0.05$) (Table 4).

A Kappa coefficient of 0.81 was determined.

Discussion

The investigation of stroke rehabilitation videos on YouTube yields substantial knowledge of the quality and features of this popular platform. Primary findings reveal that although YouTube offers diverse videos on stroke rehabilitation, considerable variation exists in their quality. Academic medical centers and nonphysician healthcare professionals were the predominant suppliers of high-quality videos, while independent users and TV channels were linked to poor content (Fig. 2).

The widespread use of narrators in stroke rehabilitation videos highlights the necessity of diversity in information delivery forms. While narrators offer comprehensive clarifications, animations, and patient stories have distinct advantages, such as improving visual learning and establishing emotional engagement. Expanding the usage of different formats can increase participation and accessibility for a broad audience [23].

The findings indicate substantial variations in the quality of stroke rehabilitation materials on YouTube. High-quality videos comprised half of the examined content, showing an extensive presence of valuable materials. However, approximately one-third of the videos were of low quality, demonstrating a diversity in informative standards. Notably, academic medical centers and nonphysician healthcare professionals are identified as the leading sources of high-quality videos, demonstrating their dedication to evidence-based and reliable instruction. On the other hand, independent users and TV channels were linked to the poorest quality videos. This sharp difference emphasizes the need for trusted sources to provide dependable information, as well as the hazards posed by uncontrolled or inexperienced contributors. These findings underline the necessity of directing users to trustworthy sources and the need for stronger content management, editing mechanisms, and quality assurance systems on the platform [5, 24]. To enhance the effectiveness of high-quality content, it is essential to aggregate all trustworthy YouTube videos on stroke rehabilitation onto specialized sites overseen by local and international stroke

Table 3 Comparison of the video parameters between the low-quality, intermediate, and high-quality groups

	Low quality	Intermediate quality	High quality	*p*
Views per day	7.69 (0.07–328.76)	67.82 (9.57–423.55)	114.44 (1.55–477.81)	<0.001
Likes per day	0.05 (0–7.18)	0.83 (0.05–6.12)	2.30 (0–6.69)	0.001
Comments per day	0 (0–0.31)	0.08 (0–0.41)	0.05 (0–0.52)	0.004

Table 4 Correlation analysis between content scores and video parameters

	GQS	Modified DISCERN Questionnaire	JAMA Benchmark Criteria	PEMAT-A/V Understandability	PEMAT-A/V Actionability
Video duration	**0.662**[a]	**0.504**[a]	**0.505**[a]	**0.485**[a]	**0.595**[a]
Days since upload	0.085	-0.015	0.041	-0.004	0.010
Views per day	**0.319**[b]	**0.245**[b]	**0.258**[b]	**0.249**[b]	**0.248**[b]
Likes per day	**0.339**[b]	**0.262**[b]	**0.254**[b]	**0.302**[b]	**0.293**[b]
Comments per day	**0.281**[b]	0.178	0.141	0.213	0.180

GQS: Global Quality Scale; JAMA: Journal of the American Medical Association; PEMAT-A/V: Patient Education Materials Assessment Tool for Audio/Visual Materials

[a] indicates $p<0.01$; [b] indicates $p<0.05$

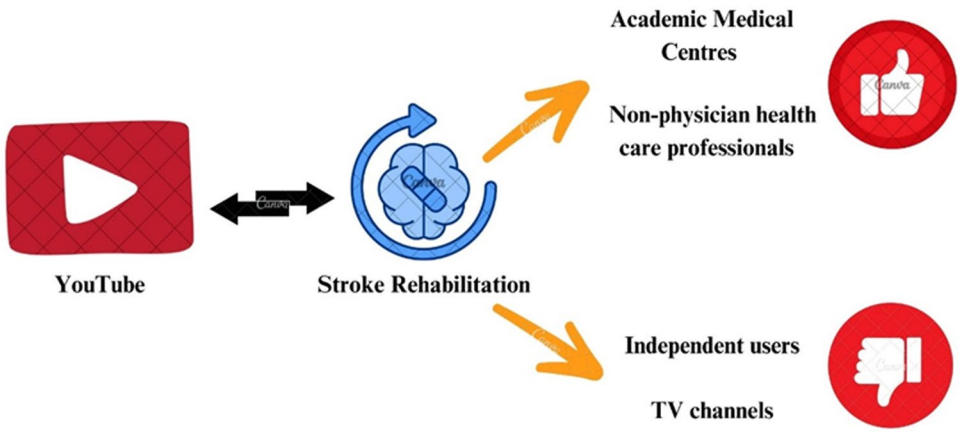

Fig. 2 High and low-quality video sources on YouTube videos related to stroke rehabilitation

societies. Centralized databases can be reliable resources for patients and healthcare professionals, providing consistent access to trustworthy educational content [25].

Significant differences across quality groups were based on daily views, likes, and comments. Low-quality videos had the poorest values for daily engagement measures involving views, likes, and comments. This suggests that low-quality videos fail to fulfill instructional criteria and struggle to pique users' interest and maintain engagement. In contrast, higher-quality videos are likely to contain more comprehensive and user-friendly material, increasing their attractiveness and utility. These findings emphasize the possible utility of user engagement measures as indirect markers of video quality [26]. However, depending solely on this data as a measure of high quality may not always be the best strategy.

The significant correlations between the GQS and other video evaluation instruments (Modified DISCERN Questionnaire, JAMA Benchmark Criteria, and PEMAT-A/V) highlight the reliability and validity of these frameworks in assessing health-related material on YouTube. These statistics demonstrate a constant concordance among different tools in detecting videos that adhere to elevated instructional accuracy, reliability, and usefulness requirements. The result underscores the complementing characteristics of varying evaluation approaches, with each instrument targeting distinct facets. Their joint application provides a thorough evaluation.

Video quality and reliability were more directly correlated with duration, with longer videos performing higher on all assessment tools. These significant correlations indicate that longer videos deliver more in-depth explanations, which is critical for stroke rehabilitation instruction. Longer videos are more likely to include elaborate demonstrations, step-by-step guidance, and in-depth explanations, increasing their instructional value [27]. However, lengthy information should be entertaining and well-structured to sustain audience interest and comprehension. These findings support prioritizing video material that balances duration, clarity, and depth, making it more effective for Internet users.

Video assessment instruments were significantly and positively correlated with views per day and likes per day data. This suggests that videos with greater engagement rates are of higher quality, as proven by their performance across various assessment metrics. Consequently, user engagement metrics may function as supplementary indicators of content quality, which would further bolster their value for discovering beneficial sources for stroke rehabilitation.

The article features several limitations, many of which stem from its design and the internal framework of YouTube. First, this article offers a snapshot of YouTube videos. Considering the constantly changing atmosphere of YouTube, the continuous uploading and publishing of new videos, and the fluctuating amount of views, likes, and comments, an identical study undertaken over another time frame may produce different outcomes. Evaluating solely English-language videos ignores videos in other languages, which reach a substantial number of Internet consumers. Using YouTube's relevance-based ranking algorithm may have biased the selection of videos.

Conclusion, rheumatic perspectives, and publishing ethics

YouTube is a promising setting for spreading stroke rehabilitation knowledge, with easily accessible and engaging content to supplement established healthcare procedures. However, the substantial variety in video quality highlights the need for more content regulation, editing processes, and the promotion of high-quality sources. Academic medical institutions and nonphysician healthcare professionals were the primary sources of high-quality videos, while independent users and TV channels were associated with poor material. Initiatives to strengthen collaboration between healthcare experts

and content developers may improve the production of evidence-based, user-friendly materials. Furthermore, encouraging different video formats—such as animations, patient experiences, story-telling, and guided exercises—may increase the attraction and application of stroke rehabilitation content on YouTube.

Stroke and rheumatic disorders exhibit comparable inflammatory pathways that may heighten stroke risk and affect rehabilitation efficacy. Patients with rheumatic diseases such as rheumatoid arthritis and systemic lupus erythematosus exhibit a heightened risk of stroke attributable to chronic inflammation, endothelial dysfunction, and coagulation irregularities [28, 29]. Appropriate stroke rehabilitation in this demographic requires customized procedures that consider physical constraints, fatigue, and disease activity. Research has emphasized the importance of comprehensive rehabilitation approaches in enhancing recovery outcomes for stroke patients with rheumatic diseases [30]. Due to the possible intricacies of rehabilitation, educational resources on platforms, including YouTube, should offer targeted assistance to meet the requirements of this subgroup, hence enhancing accessibility and efficacy.

Based on the knowledge concerning the positive and negative implications of publishing YouTube posts, it is necessary to maintain video material norms, encourage professionals in critical evaluations, and educate healthcare customers on discerning accurate data from deceptive content. Using artificial intelligence for technical reviews on YouTube may help to improve the foundation of evidence and the general quality of videos. Public health publishers should adhere to established global ethical guidelines and scientific reporting norms to present evidence-based content while safeguarding individual anonymity and security. Like academic papers, incorporating pertinent references, revealing conflicts of interest, and including additional ethical considerations can augment the legitimacy of YouTube content [31].

YouTube can become a more dependable and powerful platform for stroke rehabilitation education by focusing on evidence-based techniques and harnessing cutting-edge technologies. These efforts will not only benefit stroke survivors and their carers but will also pave the way for higher-quality health information on digital platforms.

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Declarations

Ethics approval and consent to participate No human or animal was considered as a participant. Open data analysis was performed so ethics committee approval is not required.

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Conflict of interest The authors declare no conflicts of interest.

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