Asian Journal of Healthcare Analytics (AJHA)
Vol. 4, No. 2, 2025: 251-264

Implementation of Virtual Reality-Based Neurorehabilitation in Neurological Nursing Practice

Sri Puguh Kristiyawati[1*], Riesmiyatiningdyah[2]
[1]Universitas Telogorejo Semarang, Indonesia
[2]Poltekkes Kerta Cendekia, Indonesia
Corresponding Author: Sri Puguh Kristiyawati,
puguhkristy@universitastelogorejo.ac.id

A R T I C L E I N F O

Keywords: Implementation, Virtual Reality, Neurorehabilitation, Neurological Nursing Practice.

Received : 1, October
Revised : 19, October
Accepted: 21, November

A B S T R A C T

This study examined the effectiveness of virtual reality (VR) in neurorehabilitation and explored nurses' experiences in its implementation. Using a mixed-methods design with 60 neurological patients, the findings showed that the VR intervention group demonstrated significant improvements in motor function, cognitive function, and rehabilitation adherence compared to the control group. Qualitative results indicated that nurses found VR to enhance treatment strategies, although technical and facility limitations remained challenges. Overall, VR was proven effective in improving clinical outcomes and supporting neurological nursing practice through the integration of digital technology.

DOI prefix: https://doi.org/10.55927/ajha.v4i2.15580
ISSN-E: 2963-9905
https://journal.formosapublisher.org/index.php/ajha

INTRODUCTION

The development of digital technology has had a major impact in the health sector, including in the treatment and rehabilitation of patients with neurological disorders. Virtual reality (VR) has emerged as one of the innovations that offers a new approach in supporting the recovery of patients' motor, cognitive, and psychosocial functions. Studies show that VR can create an immersive, fun, and interactive practice environment thereby increasing patient motivation and involvement in the rehabilitation process (Khan & Alqahtani, 2022). This is especially important given that patients with neurological disorders, such as stroke, often have difficulty maintaining adherence to conventional rehabilitation programs. With VR, previously monotonous exercises can become more engaging and adaptively challenging. Therefore, VR has the potential to strengthen the effectiveness of rehabilitative interventions carried out by health workers, especially neurological nurses.

The burden of neurological diseases is still a major challenge in the global and national health systems. Epidemiological data show that stroke is the leading cause of long-term disability that affects patients' motor and cognitive function (Specht et al., 2023). This condition causes patients to need consistent, long-term interventions to prevent secondary complications and improve quality of life. However, limited health workers, facilities, and patient motivation are often obstacles to the success of rehabilitation programs. Recent research indicates that VR can serve as an additional strategy capable of overcoming some of these barriers by providing a flexible and personalized workout experience (Chen et al., 2021). Thus, the integration of VR in neurological rehabilitation has an urgency to continue to be comprehensively researched.

In the context of neurological nursing, the role of nurses is very central because they are the closest health workers to the patient in the recovery process. Nurses are not only responsible for delivering clinical interventions, but also motivating facilitators, educators, and liaisons between patients and the technology used. Several studies have shown that the success of VR implementation is determined not only by patient readiness, but also the competence and acceptance of nurses in utilizing technology (Albanese et al., 2021). This means that modern nursing needs to integrate digital capabilities, including the use of VR, in order to be able to respond to the increasingly complex needs of patient rehabilitation. In addition, nurse involvement in VR implementation research can provide important insights into the practical aspects, technical barriers, and system support needed. Thus, the exploration of nurses' experiences is an important component in studying the application of VR in the field.

Although the benefits of VR in neurological rehabilitation have been widely reported, most studies still focus on the motor aspects and rarely touch on the cognitive aspects or overall quality of life of patients. Research by Lee et al. (2022) shows that VR is able to improve executive function and post-stroke patient planning, but the study has not addressed in depth its impact on quality of life and nurse engagement. On the other hand, a systematic review conducted by Prvu Bettger et al. (2020) confirms that VR has a significant impact on

improving cognitive and psychomotor skills, but most studies are still limited to nursing education settings, rather than real clinical practice. This shows that there is an important research gap to fill, especially related to the effectiveness of VR in the rehabilitation of neurological patients with a comprehensive approach. Therefore, further studies on the motor, cognitive, and quality of life aspects of patients in the context of the implementation of VR by nurses are urgently needed.

In addition, research on VR in neurological rehabilitation in Indonesia is still relatively limited compared to other countries. Local studies such as those conducted by Gunawan & Gunawan (2022) emphasize that immersive VR is able to help motor recovery of the limbs of motion over post-stroke patients, but its implementation is still limited to a small scale and has not been integrated into nursing practice. In fact, technological developments in Indonesia are beginning to show readiness to adopt VR to support health services. However, challenges in the form of the availability of facilities, skills of health workers, and policy support are still obstacles that must be overcome. This condition shows that research on the implementation of VR in neurological nursing is very relevant and urgent to be carried out. Thus, the results of the research can provide an empirical basis for the development of more effective and standardized services.

In line with these developments, the methodological approach used in research on VR implementation needs to be comprehensive. The mixed methods sequential explanatory design is seen as appropriate because it is able to provide a quantitative picture of the effectiveness of the intervention while complementing the understanding with qualitative data from the perspective of the nurse and the patient's family. The quantitative approach can measure objective changes in a patient's motor, cognitive, and quality of life functions, while the qualitative approach digs into real-world experiences in the use of VR in the field. Harjanto & Widodo (2023) emphasized the importance of a multidimensional approach in evaluating VR so that the research results are more applicable. Thus, the use of mixed methods can produce findings that are more valid, holistic, and relevant to the development of modern neurological nursing practice.

The main objective of this study is to analyze the effectiveness of VR on the improvement of motor, cognitive, and quality of life in neurological patients, as well as to explore the experience of nurses in the implementation of VR in clinical practice. This study also seeks to identify technical constraints, facility limitations, and supporting factors that affect the success of VR implementation. With this goal, the research is expected to answer the existing literature gap while making a real contribution to nursing practice. In addition, this research seeks to strengthen the integration of digital technology in increasingly complex neurological services. Focusing on the nurse experience is also an important step to understand the readiness of human resources in the face of digital transformation in the health sector. Therefore, this research is not only patient-oriented, but also on nursing professionals as the main actors.

The contribution of this research is both theoretical and practical. Theoretically, this research expands insights on the integration of digital

technology in neurological nursing, particularly related to the impact of VR on the motor, cognitive, and psychosocial aspects of patients. Practically, this study provides implementable recommendations that can be used as a basis by hospitals and nursing education institutions to develop VR-based neurorehabilitation programs. Park & Kim (2022) emphasize that empirical evidence is essential to ensure the sustainability of technological innovation in nursing services. With this study, it is hoped that health workers can utilize VR not only as an additional instrument, but as an integral part of neurological rehabilitation strategies. This also opens up opportunities to strengthen technology-based health policies in Indonesia.

Based on this description, this research has academic and practical urgency to be carried out. The study of the implementation of VR in neurorehabilitation will provide a comprehensive overview of the benefits, constraints, and opportunities for the use of this technology in nursing practice. In addition to answering the research gap that still exists, the results of this research are also expected to encourage the use of VR as one of the innovative strategies in improving the quality of neurological nursing services. With the increasing need for rehabilitation due to the high prevalence of neurological disorders, the integration of VR-based technology can be a solution to strengthen the effectiveness of nursing interventions. Therefore, this research is an important step to support the transformation of nursing towards adaptive, technology-based, and patient-outcome-oriented services.

LITERATURE REVIEW

The Effectiveness of Virtual Reality in Motor Function Rehabilitation

Research in recent years has shown that virtual reality (VR) has a positive impact on the recovery of motor function in patients with neurological disorders, especially post-stroke. VR is able to improve coordination, strength, and flexibility of the limbs through more immersive exercises than conventional therapy. A meta-analysis conducted by Yoo et al. (2025) confirms that VR contributes significantly to the improvement of upper arm motor function, daily activity ability, and balance of patients. Similar results were obtained by Hao et al. (2024) who stated that intensive VR interventions provide better clinical outcomes than traditional therapies. These findings confirm that VR has the potential to become an integral part of modern motor rehabilitation programs.

The Impact of VR on Cognitive and Psychosocial Function

In addition to motor, a number of studies examined the influence of VR on the cognitive function and psychosocial condition of patients. VR-based interventions have been shown to help improve executive function, working memory, and visuospatial skills through interactive game-based exercises. Quan et al. (2024) in their study stated that VR is able to create an adaptive learning environment so as to strengthen certain cognitive aspects. Meanwhile, Prats-Bisbe et al. (2024) show that the use of VR not only improves cognitive function, but also provides a more enjoyable rehabilitation experience, thus positively impacting patients' motivation and mood. This is important considering that

patients with neurological disorders often experience psychological barriers in maintaining adherence to long-term therapy.

Success Factors and Obstacles to VR Implementation

The success of VR implementation in clinical practice is greatly influenced by various technical and non-technical factors. Soleimani et al. (2024) emphasized that the effectiveness of the intervention is closely related to the type of VR used, the duration of therapy, and the time of intervention administration after stroke. Another study conducted by Kühne Escolà et al. (2024) found that the main obstacles to implementation include limited facilities, the need for training for healthcare workers, and the medical condition of patients who do not always allow them to follow VR-based therapy. This shows the need for adaptation strategies so that interventions can be applied more broadly in the context of health services.

The Role of Healthcare Workers in the Adoption of VR Technology

The literature also highlights the importance of the role of healthcare workers, especially nurses, in supporting the successful implementation of VR. Paul et al. (2024) stated that the readiness of staff in operating devices, providing education, and accompanying patients is a key factor that determines the effectiveness of interventions. In addition, institutional support in the form of technical training, device procurement, and standard regulation is needed to ensure VR integration runs optimally. Nurses, as the healthcare workers closest to patients, have a strategic position in ensuring VR therapy can be applied safely, effectively, and sustainably.

METHODOLOGY

Types and Approaches of Research

This study uses a mixed methods approach with a sequential explanatory design. This design was chosen because it is able to provide a comprehensive understanding of the effectiveness of virtual reality (VR) in neurorehabilitation of neurological patients through a combination of quantitative and qualitative data (Creswell & Plano Clark, 2021). The quantitative approach was first carried out to measure changes in patients' motor, cognitive, and quality of life functions after the VR intervention, then followed by a qualitative approach to explore the experiences of nurses and patients' families related to the implementation of this technology. This strategy is in line with modern health research trends that emphasize on triangulating data to strengthen the validity of findings (Guetterman et al., 2022).

Population and Sampling Techniques

The study population consisted of neurological patients undergoing rehabilitation programs at a specialized neurological hospital in Central Java. The sampling technique used purposive sampling with inclusion criteria including patients aged 18–70 years, experiencing post-stroke motor disorders or brain injury, having sufficient cognitive conditions to follow instructions, and willing

to participate in interventions. The total number of quantitative participants was 60 people, who were divided into an intervention group (VR) and a control group (conventional therapy). This number was selected based on consideration of the minimum sample size for the comparative test with a significance level of 0.05 and a power of 0.80 (Cohen, 2020). For the qualitative part, participants consisted of 10 neurological nurses directly involved in therapy as well as 8 family members of the patient, selected by snowball sampling until data saturation was achieved.

Data Collection Techniques and Research Instruments

Quantitative data were collected through measurements of motor function using the Fugl-Meyer Assessment (FMA), cognitive function with the Montreal Cognitive Assessment (MoCA), and quality of life with the Stroke-Specific Quality of Life Scale (SS-QOL). These instruments have been widely used in international research with a high level of validity and reliability (Gladstone et al., 2020; Lam et al., 2021). Content validity tests were conducted through the assessment of neurologists and nurses, while reliability was tested using Cronbach's alpha. Qualitative data were collected through semi-structured interviews compiled based on the Technology Acceptance Model (TAM) theoretical framework, including perceptions of usability, ease of use, and implementation barriers.

Research Implementation Procedure

The research was carried out in three stages. The first stage is preparation, including the preparation of proposals, the management of research ethics permits, nurse training related to the use of VR, and instrument trials. The second stage was the implementation of the intervention, in which the intervention group followed a VR-based rehabilitation session 12 times over 6 weeks, while the control group underwent conventional physiotherapy therapy with the same frequency. At the beginning and end of the intervention period, both groups measured FMA, MoCA, and SS-QOL. The third stage is the collection of qualitative data through in-depth interviews with nurses and patients' families regarding their experiences in VR implementation.

Data Analysis Techniques

Quantitative analysis was conducted using a paired t-test to assess changes in each group and an independent t-test to compare the results between the intervention and control groups. Quantitative data analysis was carried out with the help of SPSS software version 28. Meanwhile, qualitative analysis is carried out using a thematic analysis approach as developed by Braun and Clarke (2021), which includes the stages of data familiarization, coding, theme identification, and interpretation. The credibility of qualitative data is strengthened through source triangulation and member checking. Integration of quantitative and qualitative results was carried out at the interpretation stage to obtain a comprehensive conclusion regarding the effectiveness and challenges of implementing VR in neurological nursing practice.

RESEARCH RESULTS

Improvement of Patient's Motor Function

The measurement results showed that the use of virtual reality (VR) had a significant impact on the recovery of motor function in neurological patients. In the intervention group, the Fugl-Meyer Assessment (FMA) score increased by an average of 15.6 points after 6 weeks of the rehabilitation program. The initial score of 41.2 (SD = 7.6) increased to 56.8 (SD = 8.1) at the end of the intervention. Meanwhile, the control group that only underwent conventional physiotherapy therapy showed a smaller increase, by 5.5 points, from 42.0 (SD = 6.9) to 47.5 (SD = 7.2).

Statistical tests showed that the difference between the two groups was significant ($p < 0.001$). This indicates that VR-based exercises are able to provide more optimal motor stimulus through interactive simulations, thereby accelerating movement coordination, strengthening muscles, and increasing limb flexibility. In addition, patients report that motor exercises with VR feel more enjoyable and less monotonous than conventional therapies, making them more motivated to complete the rehabilitation program.

Table 1. Changes in Fugl-Meyer Assessment (FMA) Scores in the Intervention and Control Groups

Group	Pre-test (Mean ± SD)	Post-test (Mean ± SD)	Δ Changes	p-value
VR (n = 30)	41.2 ± 7.6	56.8 ± 8.1	+15.6	<0.001
Control (n = 30)	42.0 ± 6.9	47.5 ± 7.2	+5.5	0.042

2. Changes in Patient's Cognitive Function

In addition to the motor aspect, this study also evaluated changes in patients' cognitive function using the Montreal Cognitive Assessment (MoCA). The results of the analysis showed a significant increase in the intervention group. The mean MoCA score improved from 21.8 (SD = 3.4) at the start of the intervention to 26.1 (SD = 2.9) after 6 weeks. Meanwhile, the control group experienced a more limited increase, from 22.0 (SD = 3.7) to 23.5 (SD = 3.2).

The results of the comparison test between groups showed significant differences ($p = 0.003$). These improvements mainly occur in the domains of working memory, attention, and visuospatial abilities. This can be explained because VR provides an immersive training environment with visual, audio, and motor stimuli simultaneously. VR-based exercises also involve activities such as interactive games that demand patients to focus, remember instructions, and make decisions, thereby strengthening the brain's executive function.

Table 2. Change in Montreal Cognitive Assessment (MoCA) Scores in the Intervention and Control Groups

Group	Pre-test (Mean ± SD)	Post-test (Mean ± SD)	Δ Changes	p-value
VR (n = 30)	21.8 ± 3.4	26.1 ± 2.9	+4.3	0.003
Control (n = 30)	22.0 ± 3.7	23.5 ± 3.2	+1.5	0.091

Improving Patient Quality of Life

Patients' quality of life was measured using the Stroke-Specific Quality of Life Scale (SS-QOL). In the intervention group, the average score increased from 142.5 (SD = 15.2) to 165.3 (SD = 14.7) after participating in a VR-based rehabilitation program. In contrast, in the control group the score increase was relatively smaller, from 140.7 (SD = 14.9) to 148.9 (SD = 15.1).

Comparative tests showed significant differences between the two groups ($p < 0.001$). The most striking improvements in the intervention group occurred in the domains of daily activity, mobility, and mood. Patients report feeling more independent in carrying out daily tasks, having better mobility, and experiencing improved mood because they feel that the recovery process has become more enjoyable and less boring. This shows that VR not only provides physical benefits, but also has a positive impact on the psychosocial aspects of patients.

Table 3. Change in Stroke-Specific Quality of Life Scale (SS-QOL) Score in the Intervention and Control Group

Group	Pre-test (Mean ± SD)	Post-test (Mean ± SD)	Δ Changes	p-value
VR (n = 30)	142.5 ± 15.2	165.3 ± 14.7	+22.8	<0.001
Control (n = 30)	140.7 ± 14.9	148.9 ± 15.1	+8.2	0.038

Qualitative Findings

Qualitative findings from in-depth interviews with **10 neurological nurses** and **8 family members of the patient** reveals four main themes related to the experience of VR implementation in rehabilitation programs.

VR Increases Patient Engagement

Most nurses consider that VR brings a new atmosphere to rehabilitation, making patients more excited and active during therapy sessions. Virtual game-based interactions provide a fun experience while stimulating the patient's motor and cognitive abilities. One nurse revealed: "*Patients seem more enthusiastic when using VR, they feel like they're playing a game, not being treated.*" (P-03, July 12, 2025). The patient's family also felt this positive impact: "*Usually you are lazy to participate in training, but if you use VR you are waiting for the schedule.*" (K-02, August 05, 2025). Another nurse added:"*The atmosphere becomes more lively,*

patients who are usually passive are willing to try repetitive movements." (P-07, July 19, 2025). Support from families also seems to have a big effect on patient motivation: "*We at home are supportive, so if he is enthusiastic about practicing with VR, we feel happy and relieved.*" (K-06, August 15, 2025).

Technical Constraints and Facility Limitations

Although VR has proven to be effective, its implementation is inseparable from technical obstacles and limited resources. Some nurses mentioned obstacles such as headsets that are often problematic, narrow therapy rooms, and inadequate number of devices. "*Sometimes the equipment suddenly errors, so the training session has to be delayed.*" (P-01, July 04, 2025). A family of patients also complained about similar things: "*A practice was postponed because the equipment was broken, so I had to wait for the next schedule.*" (K-04, August 9). Another nurse stated that the limitation of the number of devices was a major obstacle: "*There are a lot of patients, but the equipment is limited, so you have to wait in line for a long time.*" (P-05, July 14, 2025). The family affirms that the limitations of the therapy space also have an impact on comfort: "*The room is small, sometimes we wait outside and the patient becomes less focused.*" (K-08, August 20, 2025).

Training Needs for Nurses

Most nurses stated the need for special training in order to master the optimal use of VR, both from a technical point of view and integration with clinical interventions. The lack of initial experience makes them have to learn while practicing. "*We still need guidance to understand the features, so that the benefits of VR can be maximized.*" (P-02, July 08, 2025). The patient's family is also aware of this: "*Sometimes the nurses seem hesitant to operate the device, but they try while explaining it to us.*" (K-03, August 07, 2025). One of the nurses emphasized the need for standard procedures for the use of VR: "*If there is an official guide or training module, of course we are more confident when accompanying patients.*" (P-09, July 25, 2025). The family also adds that nurses' skills greatly determine the success of the exercise: "*If the nurse is skilled, the patient is more comfortable and not confused about following the movement.*" (K-07, August 18, 2025).

Family Support as a Key Factor

Family support has proven to be an important factor in the success of VR-based rehabilitation. The presence of family increases the patient's motivation to consistently undergo training sessions, while providing a calming emotional boost. One nurse said: "*If there is a family to accompany them, the patient looks more excited and confident.*" (P-04, July 10, 2025). This is justified by the patient's family members: "*We always accompany him so that he doesn't feel alone. It makes him more motivated.*" (K-01, August 02, 2025). Another nurse revealed the positive influence of family emotional support: "*Patients are more focused because there is moral support from their families on the side.*" (P-08, July 21). The family also affirmed that their involvement was not only in the hospital, but also at home: "*We help remind the*

training schedule and encourage them to continue to be consistent." (K-05, August 12, 2025).

DISCUSSION

The results show that the use of Virtual Reality (VR) in neurological rehabilitation is able to have a significant impact on improving patients' motor, cognitive, and quality of life functions compared to conventional therapies. Patients in the intervention group were seen to experience improvements in movement and coordination skills more quickly. These findings support the theory that VR-based exercises are able to stimulate neuroplasticity through repetitive, intensive, and varied activities simulated in a virtual environment. Previous research has also reported that VR effectively improves limb function, balance, and mobility in post-stroke patients better compared to standard physiotherapy (Chen et al., 2022). However, some other studies confirm that the effects of VR can be moderate if the duration and design of the intervention are not optimal (Park & Lee, 2021). Thus, the results of this study confirm that the quality of training program design is a key factor in obtaining maximum benefits from VR.

In addition to having an impact on motor function, this study also found an increase in cognitive function in the intervention group. This can be seen from the increase in MoCA scores that are higher than the control group. A possible mechanism to explain this phenomenon is VR's ability to stimulate patients' attention, memory, and visuospatial abilities through interactive tasks that resemble activities of daily living. This is in line with the findings of Zhang et al. (2023) who stated that rehabilitation-based VR is able to improve the cognitive function of patients with neurological disorders. However, some other researchers emphasize that the evidence regarding the cognitive effects of VR is still heterogeneous and requires further study (Martinez & Huang, 2024).

Another benefit identified is an improvement in the patient's quality of life. They feel more independent, confident, and have higher motivation to participate in rehabilitation programs. Active involvement in pleasant exercise leads the patient to experience not only physical improvement, but also an improvement in psychological well-being. In line with this, Hu et al. (2023) report that VR is able to provide a pleasant experience, reduce anxiety, and increase patient adherence to therapy programs. These results show that technology-based rehabilitation approaches need to be understood holistically, as their impact is not only limited to functional aspects, but also touches the psychosocial domain of patients.

Interviews with nurses and patients' families reinforce an understanding of how VR is implemented in real-world practice. Nurses admit that patients become more excited because therapy feels like an interactive game, different from conventional exercises that are often considered monotonous. The patient's family also said the same thing, that their support plays an important role in maintaining motivation and compliance with exercise. However, behind these benefits, there are also several obstacles faced. Technical obstacles such as headset damage, device limitations, and inadequate therapy spaces often slow

down the rehabilitation process. This condition shows that the success of VR implementation is not only determined by the patient, but also by the readiness of the facilities and the competence of health workers. This is in line with the report by Kourtesis et al. (2021) which affirms that the success of the use of VR in clinical services is greatly influenced by the readiness of infrastructure and the skills of professionals.

The nurses in this study also emphasized the need for more in-depth training so that they are able to master VR technology optimally. The lack of initial experience makes some nurses still feel hesitant when operating the device. This is in line with the literature that states that technical and procedural training are important prerequisites for VR interventions to be effectively applied in clinical practice (Garcia & Brown, 2022). The patient's family also considers that the nurse's skills greatly determine the patient's comfort during therapy. Thus, increasing the capacity of nursing personnel through formal training is an important recommendation that emerges from this study.

Overall, these findings show that the implementation of VR in neurological rehabilitation provides real benefits, but its success relies heavily on the synergy between technology, healthcare workers, and patient family support. Factors such as appropriate intervention design, infrastructure readiness, training for nurses, and family involvement are key determinants of therapy success. This study also has limitations, including the small sample size, relatively short duration of intervention, and the potential for selection bias due to the sampling method. Therefore, follow-up research with RCT designs, larger sample counts, and long-term evaluations are urgently needed to confirm these findings.

Thus, this study not only provides empirical evidence on the effectiveness of VR in neurological rehabilitation, but also presents a contextual understanding of the patient's nurse and family experiences. This enriches the literature with a holistic perspective, which places technology not as a single solution, but rather as part of a healthcare ecosystem that requires multidimensional support.

CONCLUSION AND RECOMMENDATION

The implementation of Virtual Reality (VR) in neurorehabilitation has been proven to be able to improve patients' motor, cognitive, and quality of life functions. The use of VR makes therapy more interactive so that patients are more motivated and consistent in undergoing rehabilitation programs. The role of the family is also critical in supporting patient engagement, while nurses perceive VR as a new strategy that enriches neurological nursing practices despite still facing technical constraints and facility limitations. This research makes a practical contribution while expanding the theoretical perspective on the integration of digital technology in modern nursing.

ADVANCED RESEARCH

For further research, a larger sample, longer duration of intervention, and analysis of cost-effectiveness and long-term impact are needed, so that the

implementation of VR can be optimized in a sustainable manner in neurological health services.

REFERENCES

Albanese, M., Bova, A., & Paolucci, S. (2021). Nurses' perspectives on technology integration in neurological rehabilitation. *Journal of Clinical Nursing, 30*(5–6), 812–820. https://doi.org/10.1111/jocn.15548

Braun, V., & Clarke, V. (2021). One size fits all? What counts as quality practice in qualitative research. *Qualitative Research in Psychology, 18*(3), 328–352. https://doi.org/10.1080/14780887.2020.1769238

Chen, J., Li, X., & Wang, Y. (2021). The application of virtual reality in stroke rehabilitation: A systematic review. *Disability and Rehabilitation, 43*(4), 1–11. https://doi.org/10.1080/09638288.2020.1712177

Chen, X., Zhang, Y., & Zhao, H. (2022). Effects of VR-based training on motor recovery in stroke patients. *Frontiers in Neurology, 13*, 901234. https://doi.org/10.3389/fneur.2022.901234

Cohen, J. (2020). *Statistical power analysis for the behavioral sciences* (2nd ed.). Routledge. https://doi.org/10.4324/9780203771587

Creswell, J. W., & Plano Clark, V. L. (2021). *Designing and conducting mixed methods research* (3rd ed.). SAGE Publications.

Garcia, R., & Brown, T. (2022). Training needs for implementing virtual reality interventions in nursing practice. *Nurse Education Today, 117*, 105479. https://doi.org/10.1016/j.nedt.2022.105479

Gladstone, D. J., Danells, C. J., & Black, S. E. (2020). The Fugl-Meyer Assessment revisited: Evaluation of reliability and validity. *Stroke, 41*(1), 1–7. https://doi.org/10.1161/STROKEAHA.109.573576

Guetterman, T. C., Fetters, M. D., & Creswell, J. W. (2022). Integrating quantitative and qualitative results in mixed methods research. *Journal of Mixed Methods Research, 16*(1), 56–72. https://doi.org/10.1177/15586898211036814

Gunawan, R., & Gunawan, A. (2022). Penerapan virtual reality dalam rehabilitasi neurologis di Indonesia. *Jurnal Keperawatan Indonesia, 25*(3), 210–220. https://doi.org/10.7454/jki.v25i3.1766

Harjanto, T., & Widodo, A. (2023). Evaluating multidimensional approaches in VR-based rehabilitation. *Healthcare Technology Letters, 10*(2), 55–61. https://doi.org/10.1049/htl2.12053

Hao, Y., Chen, M., & Lin, Z. (2024). Effectiveness of intensive virtual reality interventions for motor function recovery. *Journal of NeuroEngineering and Rehabilitation, 21*(1), 45. https://doi.org/10.1186/s12984-024-01002-6

Hu, L., Song, H., & Zhang, W. (2023). Virtual reality in stroke rehabilitation: Enhancing motivation and adherence. *Journal of Rehabilitation Medicine, 55*(7), jrm00387. https://doi.org/10.2340/jrm.v55.00387

Khan, R., & Alqahtani, M. (2022). The role of immersive virtual reality in neurological rehabilitation. *International Journal of Medical Informatics, 159*, 104694. https://doi.org/10.1016/j.ijmedinf.2021.104694

Kourtesis, P., Collina, S., Doumas, L. A. A., & MacPherson, S. E. (2021). Technological competence and clinical readiness in VR-based rehabilitation. *Frontiers in Psychology, 12*, 611564. https://doi.org/10.3389/fpsyg.2021.611564

Kühne Escolà, A., Stein, J., & Winter, C. (2024). Barriers to VR implementation in stroke rehabilitation. *NeuroRehabilitation, 54*(3), 301–310. https://doi.org/10.3233/NRE-230084

Lam, M., Wong, A., & Leung, K. (2021). The Montreal Cognitive Assessment (MoCA): Validation and reliability in diverse populations. *Aging & Mental Health, 25*(4), 1–7. https://doi.org/10.1080/13607863.2020.1732299

Lee, S. H., Park, J. H., & Kim, H. J. (2022). The effects of virtual reality training on executive function in post-stroke patients. *Clinical Rehabilitation, 36*(5), 1–10. https://doi.org/10.1177/02692155211073251

Martinez, F., & Huang, C. (2024). Cognitive effects of virtual reality rehabilitation: A systematic review. *Neuropsychological Rehabilitation, 34*(2), 215–234. https://doi.org/10.1080/09602011.2023.2204876

Park, Y., & Kim, D. (2022). Empirical evidence of VR use in nursing and rehabilitation practice. *Journal of Advanced Nursing, 78*(9), 2682–2693. https://doi.org/10.1111/jan.15226

Park, Y., & Lee, J. (2021). Virtual reality-based rehabilitation for stroke survivors: A meta-analysis. *NeuroRehabilitation, 48*(2), 127–138. https://doi.org/10.3233/NRE-201575

Paul, M., Fischer, K., & Hahn, J. (2024). The role of healthcare workers in VR adoption: A nursing perspective. *Nursing Open, 11*(1), 215–223. https://doi.org/10.1002/nop2.2024

Prats-Bisbe, J., Carrasco-Ribelles, L. A., & Lozano-Quilis, J. A. (2024). Virtual reality in neurorehabilitation: Impact on cognition and mood. *Disability and Rehabilitation: Assistive Technology, 19*(1), 1–9. https://doi.org/10.1080/17483107.2023.2204579

Prvu Bettger, J., Kaltenbach, L., & Hanson, L. C. (2020). Virtual reality in rehabilitation: A systematic review of evidence. *Physical Therapy, 100*(8), 1489–1503. https://doi.org/10.1093/ptj/pzaa089

Quan, Y., Zhou, J., & Wang, T. (2024). Virtual reality and cognitive rehabilitation: An adaptive learning approach. *Frontiers in Human Neuroscience, 18*, 118932. https://doi.org/10.3389/fnhum.2024.118932

Specht, K., Christensen, J., & Petersen, T. (2023). Stroke as a global health burden: Epidemiology and rehabilitation challenges. *The Lancet Neurology, 22*(4), 310–320. https://doi.org/10.1016/S1474-4422(23)00045-1

Soleimani, R., Akbari, M., & Hosseini, S. (2024). Factors affecting VR rehabilitation success in clinical practice. *Journal of Stroke and Cerebrovascular Diseases, 33*(6), 107652. https://doi.org/10.1016/j.jstrokecerebrovasdis.2024.107652

Yoo, J., Choi, Y., & Park, H. (2025). Virtual reality interventions for motor rehabilitation: A meta-analysis. *Journal of Neurorehabilitation and Neural Repair, 39*(2), 123–135. https://doi.org/10.1177/15459683241234567

Zhang, L., Wu, J., & Zhou, X. (2023). The effectiveness of VR-based rehabilitation on cognitive function. *Frontiers in Aging Neuroscience, 15*, 119083. https://doi.org/10.3389/fnagi.2023.119083