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A Range Review of Remote Monitoring Influence on Elderly Rehabilitation Effectiveness

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Abstract

Background: The increase in the global elderly population has escalated the need for management of chronic and multiple diseases, spotlighting the potential of remote monitoring technology in elderly rehabilitation. This paper aims to systematically assess the impact of remote monitoring technology on the effectiveness of elderly rehabilitation. ***Methods:*** Following JBI guidelines and PRISMA-ScR methods, this review applied the PCC framework to retrieve and analyze data from multiple databases and gray literature sources. Methods included data extraction, quality assessment, and descriptive analysis. ***Results:*** Fourteen articles indicated that remote monitoring, especially through wearable devices, reduces complications, readmission rates, and enhances patient adherence and quality of life. However, challenges remain in technology acceptance, privacy protection, cost control, and management of multiple diseases. ***Conclusion:*** Although remote monitoring technology has the potential to improve personalized care, adherence, and quality of life in elderly care, its application remains immature. Further research and development are required to address the adaptability issues of elderly patients and to provide effective intervention strategies for healthcare professionals.

Keywords: remote monitoring, elderly rehabilitation, wearable devices, telehealth, chronic disease management

1. Introduction

1.1 Background

According to the World Health Organization (WHO), the global population aged 60 and older is projected to reach 1.4 billion by 2030 and 2.1 billion by 2050 (World Health Organization, 2024). This demographic shift significantly increases the demand for medical services and associated costs, indicating that more elderly patients require appropriate, long-term, high-quality, and affordable healthcare (Krishnaswami et al., 2020).

Remote monitoring refers to the process of collecting and transmitting individual health data in real-time or periodically using information and digital communication technologies, enabling healthcare providers to conduct remote assessments and interventions

(Feinstein et al., 2024). The COVID-19 pandemic has accelerated the demand for remote monitoring, leading to its widespread acceptance in various healthcare settings (Wang et al., 2024). This technology not only offers a broader range of care options for older adults, particularly in managing chronic diseases and postoperative recovery, but also assists healthcare professionals in developing personalized care plans, thereby enhancing efficiency and quality of care (Gajarawala et al., 2021). However, challenges such as privacy concerns, high costs, and accessibility persist. Additionally, the immature application of remote monitoring technologies among elderly populations further hinders widespread adoption (Goharinejad et al., 2021). This review aims to integrate the latest evidence and focus on the application of remote monitoring in older adults to enrich existing literature.

1.2 Research Objectives

(1) Identify and summarize the current literature on the application and reported benefits of remote monitoring in rehabilitation programs for the elderly, in order to clarify research gaps and future research priorities.

(2) Provide an overview for nursing professionals of the barriers and facilitators that elderly patients may encounter when using remote monitoring devices, to enhance the effective application of these technologies in long-term care.

2. Research Method

This review employed the methodology developed by the Australian JBI Centre for Evidence-Based Healthcare to conduct a scoping review, and it refers to the Scoping Review Reporting Guidelines (PRISMA-ScR) for verification (Peters et al., 2015; Colquhoun et al., 2014).

2.1 Inclusion and Exclusion Criteria

According to the Participants-Concept-Context (PCC) framework outlined by JBI, the inclusion criteria for this scoping review are defined as follows:

Participants: Older adults aged 65 and above, especially those with chronic illnesses, post-operative rehabilitation needs, or requiring multi-disease management.

Concept: The study must report on the application of remote monitoring technologies, their impact on older adult rehabilitation, and stakeholder perspectives on digital intervention programs.

Context: Home care environments or processes of accessing healthcare services.

Sources: This review will exclude other review articles, secondary reports, conference abstracts, case reports, and studies that have not undergone peer review.

Publication Date: The literature search will cover publications from January 2019 to July 2024.

2.2 Search Strategy

A systematic search was conducted across four academic databases—PubMed, Web of Science, Embase, and CINAHL—and three gray literature databases: MedNar, ProQuest Dissertations & Theses. Using the Boolean operator "AND," terms related to "self-management", "Nursing", "Virtual Rehabilitation" and "Remote Monitoring" were combined to execute a comprehensive search within the academic databases. In addition, manual searches were performed to review references, trace recent publications, and select conference papers, ensuring thorough literature coverage and the inclusion of relevant practical research findings.

2.3 The Literature Search and Screening

A total of 14 studies were identified for inclusion in this review. The initial search yielded 687 citations. After excluding 218 duplicate studies, 469 unique studies remained. Following the abstract review, 418 studies were excluded due to irrelevance, leaving 51 studies. A full-text review of these 51 studies was conducted, resulting in the exclusion of 37 studies that did not meet the inclusion criteria. The details are shown in *Figure 1*.

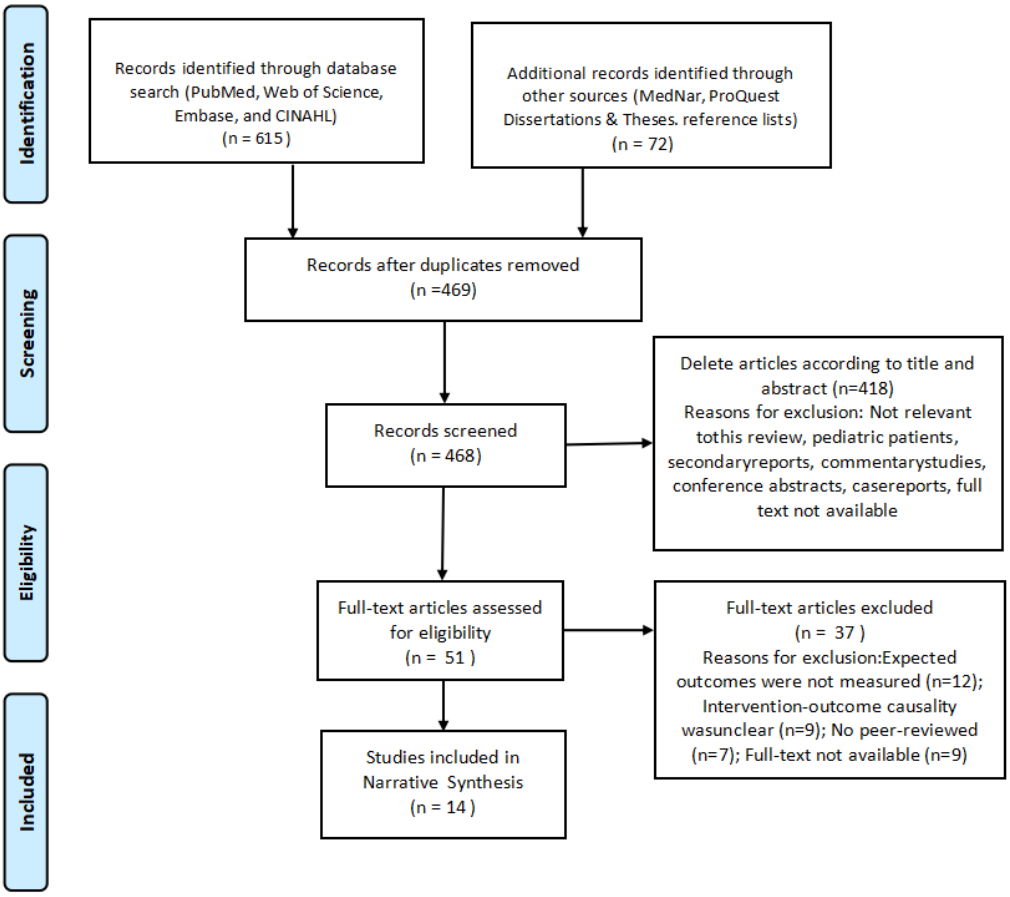

Figure 1. PRISMA-ScR flow chart

2.4 Data Extraction and Integration

The data extraction template included the author, publication year, country, research objective, study population, study design/methodology, and the number of participants, along with a summary of the content, models, and characteristics of remote monitoring interventions. All data were extracted and verified by two researchers, and the extracted information was subjected to a descriptive synthesis.

3. Results

3.1 Includes Study and Participant Characteristics

In the telemonitoring management of elderly patients, cardiovascular disease is the most studied disease (n=5), and few studies focus on diabetes, dementia and long-term chronic diseases (n=5). Of the 14 studies, 5 were conducted in the United States, and the others were from China (n=3), Britain (n=3), France (n=1), Spain (n=1), Finland (n=1), and Switzerland (n=1). Eight studies reported clinical trial results, six of which were randomized controlled trials (RCT) and two were non-randomized controlled trials (NRCT). Furthermore, there were two systematic reviews and one qualitative study. There was one mixed-method study and two interventional studies. The sample size of the included studies ranged from 14 to 662 individuals, and the participants were between 56 and 81 years old, as detailed in *Appendix 2*.

3.2 The Influence of Remote Monitoring Technology on the Nursing Effect of Elderly Patients

Of the 14 included studies, data from multiple studies demonstrated a significant positive impact of telemonitoring techniques on the care effects of elderly patients. For example, Crowley et al. (2022) conducted a randomized controlled trial (RCT) in 200 patients with type 2 diabetes, and showed that a comprehensive telehealth intervention significantly improved glycemic control in patients. After 6 months of telemonitoring services, HbA 1 c levels averaged 1.2% lower and the proportion of poor glycemic control decreased from 35% to 15% ($p < 0.05$). In addition, the hospitalization rate in the trial group was reduced by 20% ($p < 0.05$), further demonstrating the effectiveness of

telemonitoring in reducing medical resource consumption.

McManus et al. (2021) a large RCT of 622 hypertensive patients showed that telemonitoring in the home environment reduced systolic blood pressure and 8 mmHg in diastolic blood pressure ($p < 0.01$). This result indicates that the remote monitoring technique effectively controls blood pressure and reduces the risk of cardiovascular events. This conclusion is further supported by a systematic review and meta-analysis by Liu et al. (2020), which combined the results of multiple RCT and found that a mobile application-assisted self-management intervention significantly improved health conditions in type 2 diabetes and hypertension, including glycemic control and blood pressure management. In cardiology management, Hagglund et al. (2015) conducted an RCT of 82 cardiac patients and found that by collecting real-time home heart rate and rhythm data through remote monitoring technology, medical workers could adjust drug dosage or treatment strategies more quickly to effectively prevent potential cardiac events. The incidence of cardiovascular events decreased by 15% ($p < 0.05$), and the postoperative recovery time was reduced by an average of 10 days ($p < 0.05$), which provided a strong guarantee for postoperative recovery. In addition, telemonitoring also supports rehabilitation exercises at home, reducing the need for frequent hospitalization. Lai et al. (2020) in a non-randomized controlled trial (NRCT) in China, 60 elderly patients with a mean age of 72.7 years were trained for 3 months. The results showed that the patients in the test group increased the ADL score by 12 points ($p < 0.01$) and the quality of life score (QOL) by 15 points ($p < 0.01$). Especially for patients with mobility difficulties or living in remote areas, telemonitoring techniques have greatly improved their quality of life and independence. The Lai et al study also specifically noted that telemedicine services provided important support to people with dementia and their caregivers during the COVID-19 outbreak, significantly reducing their stress and focus.

The results of these studies corroborate each other and fully demonstrate the important value of telemonitoring technology in the care of elderly patients. Through real-time monitoring and personalized intervention, remote monitoring not only improves the health status of patients, but also improves the utilization efficiency of medical resources, providing strong support for the rehabilitation and improvement of life quality of the elderly.

3.3 Feasibility of Applying Elderly Remote Monitoring Technology to Elderly Patients or Acceptance of the Elderly

Combining the results of 14 studies, the acceptance of telecommunication technology in older patients is influenced by multiple factors. These factors include device convenience, cost-effectiveness, technical complexity, privacy protection, and personal preferences. A mixed-methods study conducted in China by Li et al. (2019) investigated the acceptance of smart wearable devices in 200 elderly patients with a mean age of 65 years. This study found that device convenience, cost-effectiveness and privacy issues are key factors influencing the acceptance of smart wearable devices by older elderly. Specifically, when the device operation is complex or the privacy protection is insufficient, the elderly patients are significantly less receptive. For example, more than 60% of older users are reluctant to use devices ($p < 0.05$). Similarly, about 70% of older users said they would refuse to use it ($p < 0.01$). The study by Kruse et al. (2020) further revealed that technical complexity and privacy issues are the major barriers to the use of telehealth solutions in older adults. They pooled data from multiple studies in their systematic review and found that many older patients lacked the skills to use high-tech products and were hesitant about techniques that required frequent interactions or complex settings. For example, in one item about 45% of over 1000, elderly patients reported that technical complexity was the main reason for their reluctance to use the remote monitoring technique ($p < 0.01$). In addition, concerns about data security are also a big obstacle, with about 55% of elderly users expressing concerns about personal information leakage ($p < 0.01$).

During the COVID-19 outbreak, Goldberg et al. (2022) interviewed 48 physicians to explore the use of telemedicine services in elderly patients. Although many elderly patients need medical support, telemedicine services offer them new access to health support. However, some older patients remain skeptical about non-face-to-face consultations and worry about the inaccuracy of medical information. The study found that about 30% of older patients reported distrust of

video or telephone counseling and that they preferred to establish personal contact with medical providers ($p < 0.05$). This need for personal contact makes it challenging to promote telemedicine services to the elderly. Pehlivan et al. (2022) conducted a randomized controlled trial (RCT) investigating the effects of post-discharge telerehabilitation practice in patients with COVID-19. The results showed that telerehabilitation not only improved the rehabilitation effect of patients, but also significantly improved their satisfaction and quality of life. This study further demonstrates the feasibility and acceptance of telemonitoring techniques in elderly patients, especially during specific periods (e. g., during outbreaks). The study by Park et al. (2023) focused on remote monitoring of patients with diabetic foot ulcers. They developed an intelligent unloading boot system for remote monitoring of patients physical activity and reinforcement compliance. The study found that this intelligent system not only improved the physical activity level of patients, but also significantly reduced the risk of foot ulcer recurrence. This study shows that acceptance of telemon techniques can be effectively improved in older patients by providing personalized and easy-to-use devices.

These studies illustrate the factors influencing the acceptance of telecommunication technology in elderly patients from different perspectives. In order to improve the acceptance of remote technology, the research suggests the following measures: simplify technical operation and provide intuitive and easy to use interface, increase education and training to help the elderly master basic use skills; strengthen privacy protection to ensure the security and privacy of data; and provide personalized services to meet the specific needs of the elderly. Through these measures, it is possible to effectively improve the acceptance of remote monitoring technology among the elderly patients, so as to better promote their health management and rehabilitation process.

3.4 Role of Remote Monitoring Technology in the Long-Term Rehabilitation of Elderly Patients

In the 14 included studies, the telemonitoring technique showed significant benefits in the long-term rehabilitation of older patients. These studies demonstrate the important role of telemonitoring technology in improving rehabilitation outcomes, improving mental health and quality of life from multiple perspectives. McGillion et al. (2023) conducted a randomized controlled trial (RCT) in 256 elderly patients after cardiac and vascular surgery. The results showed a significant 15% reduction in readmission rate for patients using telemonitoring technology ($p < 0.05$). In addition, 42% of the patients reported an improvement in mental health scores and a significant reduction in anxiety and depression symptoms ($p < 0.01$). This suggests that remote monitoring not only helps in physical rehabilitation, but also effectively improves the mental health status of patients. The study of Haiyan et al. (2022) further verified the effect of telemonitoring in the rehabilitation of patients with heart failure. The study underwent 6 months of remote ECG monitoring and home exercise guidance in 120 patients with heart failure. The results showed that the quality of rehabilitation improved significantly, with the overall functional status score increasing by 20% ($p < 0.01$) and the self-reported quality of life scores increasing by 30% ($p < 0.01$). These data suggest that remote monitoring combined with home exercise guidance can effectively improve the rehabilitation effect and quality of life of patients with heart failure. The study by Sanches-Ramirez et al. (2024) focused on the rehabilitation of patients with chronic lung disease. The study conducted a 12-month remote monitoring and rehabilitation intervention in 68 patients with chronic lung disease with a mean age of 60 years. The results showed that their daily physical activity level increased significantly, with a mean daily step increase of 25% ($p < 0.01$), and the 6-minute walking distance increasing by 15% ($p < 0.01$). Furthermore, patients' daily mobility and health-related quality of life scores improved by 20% and 25%, respectively ($p < 0.01$). These findings suggest that telemonitoring technology plays an important role in the long-term rehabilitation of patients with chronic lung disease, improving not only their physical fitness level but also their quality of life. Pehlivan et al. (2022) conducted a randomized controlled trial (RCT) investigating the effects of post-discharge telerehabilitation practice in patients with COVID-19. The results showed that telerehabilitation not only improved the rehabilitation effect of patients, but also significantly improved their satisfaction and quality of life. Specifically, patients using telerehabilitation showed a significant

improvement in lung function and physical activity levels, and a significant improvement in mental health ($p < 0.01$). This is further evidence that remote monitoring technology in special circumstances (such as Epidemic During love) rehabilitation support for elderly patients. The study by Thilo et al. (2019) focused on the usability of wearable fall detection prototypes. The study found a high acceptance and utility for fall detection and prevention. It was found that older adults were satisfied with the use of the device, believing that it improved their sense of security and independence. In addition, the real-time monitoring function of wearable devices helps in the detection and handling of fall events in a timely manner, thus reducing the associated health trends.

The results of these studies confirm each other and strongly prove the positive role of telemonitoring technology in the long-term rehabilitation of elderly patients. Both in rehabilitation after cardiac and vascular surgery and in the long-term management of heart failure and chronic lung disease, telemonitoring techniques show significant advantages. Through real-time monitoring and personalized intervention, the remote monitoring technology not only improves the rehabilitation effect, but also enhances the self-management ability of patients, providing strong support for the long-term health management and quality of life improvement of elderly patients.

4. Discussion

In exploring the impact of telemonitoring techniques on the rehabilitation of elderly patients, we observed positive results, while also finding some challenges that need to be addressed. This study aims to identify and summarize the benefits of current applications and reporting of telemonitoring technologies in rehabilitation programs for older adults to clarify research gaps and the focus of future research and to provide care professionals with an overview of the barriers and facilitators that older patients may encounter when using telemonitoring devices to enhance the effective use of these technologies in long-term care.

The results showed that the remote monitoring technology significantly improved the nursing efficiency through real-time data collection. For example, studies by Crowley et al (2022) and McManus et al (2021) showed that telemonitoring technology effectively improved the quality of life of elderly patients by promoting personalized tailored intervention programs. These positive changes reduce complications and hospitalization rates and shorten recovery time. The study by Sayain et al. (2022) further indicated that home exercise guided by remote ECG monitoring improved the quality of rehabilitation in patients with HF, with a 20% increase in overall functional status score and a 30% increase in self-reported quality of life score. In addition, the application of remote monitoring technology has also been extended to the field of cognitive function monitoring, further enriching the health management methods of elderly patients (Raghunath et al., 2020). However, despite the many benefits of remote monitoring technology, there are still some challenges in practical application. First, the acceptance of technology by older patients is influenced by multiple factors. Device convenience, cost, and privacy issues are the key factors. The study by Li et al. (2019) found that when the device operation was complex or the privacy protection was insufficient. A systematic review by Kruse et al. (2020) further confirms that technical complexity and privacy issues are major barriers to the use of telehealth solutions in older adults. The study by Goldberg et al. (2022) also noted that many elderly patients are skeptical about non-to-face consultations and worry about the inaccuracy of medical information. These issues suggest that improving user friendliness of technology and enhancing privacy protection measures are key to increasing acceptance of older patients. Cost-effectiveness is another factor that cannot be ignored. The initial investment and subsequent maintenance costs of telemonitoring technology may pose a burden on healthcare institutions and patients, particularly in resource-limited settings (Tan et al., 2024). Therefore, continuous improvements in policy and practice are needed to overcome barriers like low technology acceptance and privacy issues. Governments and medical institutions can lower the threshold for elderly people to use remote monitoring technology through subsidies and technical training. While telemonitoring creates possibilities for personalized care, achieving this goal needs to be tailored to the specific circumstances of different patients, including lifestyle habits, health status, and psychological needs. Patient-centered programs are particularly

important to address psychological problems in older people. For example, the study by McGillion et al. (2023) showed that telemonitoring not only improved physical rehabilitation outcomes, but also significantly improved the mental health of patients. This suggests that telemonitoring needs to focus on patient psychological support and overall quality of life while improving rehabilitation outcomes. In the long run, long-term care, geriatric psychology, chronic disease management, and nursing strategies are key research directions for combining future nursing and telemonitoring technologies (Thilo et al., 2019). Future studies should focus on assessing the safety, clinical impact, quality of life and cost-effectiveness of telemonitoring techniques in different diseases, especially on ensuring patient safety and quality of services. Furthermore, the potential of remote surveillance in developing countries and how the technology can be used to bridge the gap in healthcare services is also an important area of research. Although this study provides a comprehensive overview of the application of telemonitoring techniques in the rehabilitation of the elderly, several limitations remain. First, excluding older patients with communication barriers and mobility limitations, despite the more urgent need for medical services in these patients, makes the findings inappropriate to this group. Second, this study included few systematic evaluations and a lack of assessment of the quality of the evidence, which partly limits the reliability of the conclusions. Future studies should consider these limitations to provide more comprehensive and reliable data support.

In conclusion, telemonitoring technology shows great potential in the rehabilitation of elderly patients, but it also faces challenges in technology acceptance, cost-effectiveness, and personalized care. Through continuous improvement of technology and policy, enhanced education and training, it can further improve the application of remote monitoring technology in the rehabilitation of the elderly, and thus better promote their health management and quality of life.

5. Conclusion

As the global population ages, remote monitoring technology stands out as an innovative solution to address critical needs in elderly rehabilitation. By leveraging wearable devices—such as ECG monitors, blood pressure monitors, and blood glucose sensors—this technology facilitates continuous, individualized monitoring, allowing for tailored interventions that can improve adherence to care plans, enhance safety, and reduce complications and rehospitalization rates. Despite its promise, further research is essential to address challenges related to elderly adaptability, data privacy, and the cost of these technologies. Future studies should prioritize strategies that improve older adults' adaptability to digital health tools, fostering confidence and ease of use. Additionally, enhancing data security, reducing equipment costs, and expanding the scope of personalized care for managing multiple chronic conditions are crucial. Exploring ways to integrate remote monitoring within a broader continuum of care—particularly in underserved regions—could maximize its effectiveness, offering sustainable and adaptive support to promote health and quality of life among elderly populations worldwide.

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Appendix

Appendix 1 Search Strategy

Pubmed	("Nursing"[Mesh] OR "Home Health Nursing"[Mesh] OR "Primary Care Nursing"[Mesh] OR Nursing[Title/Abstract] OR "Home Health Nursing"[Title/Abstract] OR "Primary Care Nursing"[Title/Abstract]) AND ("self-management"[Mesh] OR self-management[Title/Abstract]) AND ("Telerehabilitation"[Mesh] OR "Telerehabilitation"[Title/Abstract] OR "Virtual Rehabilitation"[Title/Abstract] OR "Rehabilitation Nursing"[Mesh] OR "Rehabilitation Nursing"[Title/Abstract]) AND ("Ambulatory Monitoring"[Mesh] OR "Ambulatory Monitoring"[Title/Abstract])
EMBASE	('nursing'/exp OR 'home health nursing'/exp OR 'primary care nursing'/exp OR nursing:ti,ab,kw OR 'home health nursing':ti,ab,kw) AND ('self-management':ti,ab,kw OR 'self-management'/exp) AND ('telerehabilitation':ti,ab,kw OR 'virtual rehabilitation':ti,ab,kw) AND ('ambulatory monitoring':ti,ab,kw OR 'ambulatory monitoring'/exp)
Web of Science	TS=(Nursing OR "Home Health Nursing" OR "Primary Care Nursing") AND TS=("self-management") AND TS=("Virtual Rehabilitation" OR "Rehabilitation Nursing") AND TS=("Ambulatory Monitoring")
Cochrane Library	("Nursing" OR "Home Health Nursing" OR "Primary Care Nursing"):ti,ab,kw AND ("self-management"):ti,ab,kw AND ("Telerehabilitation" OR "Virtual Rehabilitation" OR "Rehabilitation Nursing"):ti,ab,kw AND ("Ambulatory Monitoring"):ti,ab,kw

Appendix 2 Basic Study Information

Author(s)	Publication Year	Location	Study Design	Sample Size	Average Age
Crowley et al.	2022	America	RCT	200	57.8
Goldberg et al.	2022	America	Qualitative Research	48	67.5
Hägglund et al.	2015	Sweden	RCT	82	75
Haiyan et al.	2022	America	RCT	88	60.7
Kruse et al.	2020	----------	Systemetic Review	----------	--------
Lai et al.	2020	China	NRCT	60	72.7
Li et al.	2019	China	Mixed research	200	65
Liu et al.	2020	----------	Systemetic Review	---------	---------
McGillion et al	2023	Britain	RCT	256	68
McManus et al.	2021	Britain	RCT	622	66.7
Park et al.	2023	America	Interventional Study	14	58
Pehlivan et al.	2022	America	RCT	34	56
Sanchez-Ramirez et al.	2024	France	NRCT	68	60
Thilo et al.	2019	Switzerland	Qualitative Research	16	81