Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/ywwcmc05

EFFECTIVENESS OF TELEMEDICINE FOR CHRONIC DISEASE MANAGEMENT IN RURAL POPULATIONS: A SYSTEMATIC REVIEW OF RANDOMIZED CONTROLLED TRIALS AND OBSERVATIONAL STUDIES

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ABSTRACT

Background: Rural populations often face significant challenges in accessing healthcare services due to geographical isolation, limited healthcare infrastructure, and scarcity of medical professionals. Chronic diseases such as diabetes, hypertension, cardiovascular diseases, and chronic obstructive pulmonary disease (COPD) are prevalent in these regions, requiring continuous care and monitoring. Telemedicine has emerged as a potential solution to bridge this gap by enabling remote healthcare delivery through telecommunication technologies.

Objective: This systematic review aims to determine the extent of effectiveness of telemedicine interventions in care delivery for chronic diseases among rural populations. Hence, the specificity of the review is to investigate the effects that telehealth entails for health outcomes, health care use, and client satisfaction in the ambiance of rural health delivery.

Methodology: The source of information was RCTs and observational studies that can inform on telemedicine and chronic diseases in particular. In fact, the quality of studies was evaluated and necessary data on the type of telemedicine interventions, patient outcomes, and cited advantages were identified and analyzed.

Results: In the telemedicine interventions analysis the review highlighted that clients with chronic diseases had improved disease status, fewer hospitalizations, and better health-related quality of life. Moreover, the studies also showed that patients are satisfied with the telemedicine interventions. Nevertheless, factors that were cited as factors that hindered dissemination of Health included; accessibility to technology, patient involvement, and health literacy.

Conclusion: Chronic disease meant telemedicine could reduce health disparities for patients from rural areas. Although it leads to better health and happier clients, extending the impact of this tool requires addressing technological factors and engaging the patients in rural care.

Keywords: Telemedicine, chronic disease management, rural healthcare, healthcare accessibility, self-management, diabetes, hypertension, cardiovascular diseases, randomized controlled trials, observational studies, technology barriers, patient education.

1. INTRODUCTION

Telemedicine is defined as the delivery of healthcare services through the use of information and telecommunication technologies, and has been widely adopted in healthcare as a way of addressing the problems faced by a growing population in rural settings. It is widely known that rural populations experience numerous challenges in regard to gaining access to healthcare services and receiving adequate medical attention (Kruse et al., 2018). As would be expected, there are significant distances between health facilities in most rural regions, becoming challenging for clients to receive proper health care particularly from chronic diseases including diabetes, hypertension, cardiovascular diseases, and COPD. Such diseases are common and lifelong, requiring constant treatment, a feat that is difficult in rural areas where access to specialist services is limited.

Chronic diseases are also some of the key causes of morbidity and mortality globally with rural populace often bearing the brunt (Boulanger et al., 2017). For instance, higher prevalence of multiple chronic diseases, and high risks of hypertension and diabetes, which are difficult to control for when health care access is steady (Bennett et al., 2018). The world health organization indicates that chronic diseases are the leading cause of death, accounting for over 70% of global mortality and the rates of chronic diseases are projected to rise in the future (World Health Organization, 2018). Older populations in rural areas coupled with high incidences of chronic illness mean that the communities require effective management practices as never before.

Telemedicine is becoming the answer to these obstacles because it uses technology in consultations, monitoring, and individual care. It has been established that home health care has benefits for patients experiencing barriers to healthcare access including location, mobility or availability of healthcare resources (Dinesen et al., 2016). Telemedicine enables healthcare practitioners to supervise the patients' conditions, offer advice and schooling, and all of that play a major role in the effective administration of chronic illnesses (Bashshur et al., 2016). Telemedicine can be as basic as a video conference to address service needs or as complex as monitoring devices for blood pressure, glucose levels and other parameters that are essential in chronic disease patients' care continuum.

Telemedicine has received great attention in terms of its capacity to deal with chronic diseases, especially in rural areas. Numerous randomized controlled trials and various observational investigations have assessed the effects of telemedicine on disease management, patient satisfaction, use of healthcare services and health care costs (Bashshur et al., 2016; Reiners et al., 2020). In particular, studies have highlighted a set of potential benefits of telemedicine for patients and caregivers, including increased self-care, decreased rates of rehospitalizations, and better disease outcomes when implemented with telemonitoring tools and telehealth education (Greenwood et al., 2017). Moreover, research has suggested that telemedicine interventions can decrease overall cost of care due to fewer in person encounters, decrease in travel expenses and possibly lessen emergency department use and hospitalizations (Caffery et al., 2017).

However, there is a great interest as well as empirical support now demonstrating the utility of telemedicine but there are limitations and questions concerning its effectiveness in rural areas. Telemedicine interventions can be effective, however the level of influence is moderate depending on the technology availability in hospitals, patient literacy, provider training, and type of chronic conditions that are being treated (Coughlin et al., 2019). However, data of pilot works and small scale trials are desirable, but the large-scale, high methodological quality of research is still lacking large sample studies, long-term follow-up results and cost-benefits. At the same time, implementation of telemedicine in rural healthcare is an essential issue that faces infrastructure issues, including the problem of the internet connectivity and organizational and legal barriers (Poon et al., 2020).

Hence, this systematic review seeks to present the collective and current evidence from RCTs and observational studies about the efficiency of telemedicine for managing chronic disease populations

in rural areas. The review will evaluate the clinical efficacy, hospital utilization rate, patients' satisfaction and cost analysis to evaluate the policies and the possibility of using telemedicine to enhance healthcare provision in EAs.

2. METHODOLOGY

Study Design

This systematic review is concordant with this view and seeks to use both published RCTs and observational studies to evaluate the impact of telemedicine interventions in managing chronic diseases in rural populations. To provide reference for the assessment on clinical relevance and patient satisfaction, the review concentrates on papers that compare telemedicine with conventional practices in terms of patient clinical status, health care consumption, patient satisfaction and costs. This methodology follows the recommendations concerning the reporting of systematic reviews and meta-analyses according to the PRISMA statement (Moher et al., 2009). Inclusion criteria for the considered studies were the type of their design (RCTs and observational studies) and the focus of the research. Due to the variability of the study designs, we decided to perform a qualitative pooling instead of a meta-analysis because pooling different study designs could be off by a large magnitude.

Selection Criteria

The inclusion criteria evolved to ensure only the most relevant studies were included in the question on the use of telemedicine in rural clients with chronic diseases. The studies under consideration were supposed to be consistent with the selection of criteria to select the relevant and scientifically sound studies.

Inclusion Criteria

The inclusion criteria for this systematic review were as follows: Studies included were only those conducted with peer-reviewed RCTs and observational studies, the two types of studies known to provide credible data on the effectiveness of an intervention as well as its impact as delivered in practice settings. The targeted population was rural people meaning those living in areas that have little access to health facilities and workers including the relatively remote regions with poor health services. Studies included in this topic analysis targeted chronic illnesses, including diabetes, hypertension, heart failure, stroke, and COPD chronic diseases due to their continuous and recurrent nature and thus amenable to telemedicine-based interventions. To participate, the studies had to assess telemedicine interventions including video consultation, remote health checks, telehealth education and telemonitoring platforms. Moreover, for the purposes of this review, studies had to provide at least one clinical end-point (which was defined as the ability in maintaining target blood pressure, HbA1c or hospitalization rate) or healthcare utilization end-point in order to evaluate the role of telemedicine for chronic disease management.

Exclusion Criteria

Telemedicine based interventions were referred if a study incorporated face to face consultations or conventional in person health care services. Papers on acute illnesses or any conditions that would be categorised under emergency were also not included as they do not fall within the realms of chronic disease management. Further, investigations relating to urban based or subjects not predominantly related to rural areas were omitted due to geographical context. Studies conducted in languages other than English were omitted because of language barriers and those which did not provide sufficient data for the identified endpoints, including clinical outcome, cost and cost-effectiveness, and patient satisfaction scores were also excluded from this review.

Search Strategy

A comprehensive search was conducted across several databases, including PubMed, Cochrane Library, Scopus, and Google Scholar, to identify relevant studies published up to October 2024. The

search utilized a combination of keywords and Medical Subject Headings (MeSH) terms, including "telemedicine," "chronic disease," "rural populations," "randomized controlled trials," and "observational studies." Additionally, reference lists from relevant reviews and included studies were screened for further relevant studies. All included studies were required to meet the predefined inclusion criteria based on their titles, abstracts, and full-text articles. The initial search was conducted in October 2024, and studies were selected based on relevance to the research question.

Study Question

The central research question guiding this systematic review is:

"What is the effectiveness of telemedicine interventions in managing chronic diseases in rural populations, with regard to clinical outcomes, healthcare utilization, patient satisfaction, and cost-effectiveness?"

This question addresses the core areas of concern for healthcare providers, policymakers, and rural patients, as effective chronic disease management can significantly improve health outcomes and quality of life in underserved areas.

Table 1: PICOS Framework for Research Question

Component	Description
Population	Rural populations, defined as individuals living in geographically isolated areas with limited access to healthcare services.
Intervention	Telemedicine-based interventions, including remote monitoring, video consultations, and telehealth education.
Comparator	Standard care, in-person consultations, or no intervention (where applicable).
Outcome	Clinical outcomes (e.g., blood pressure, HbA1c levels), healthcare utilization (e.g., hospital readmissions, ER visits), patient satisfaction, and cost-effectiveness.
Study Design	Randomized controlled trials (RCTs) and observational studies (cohort and cross-sectional studies).

Data Extraction

The data extraction process was done separately by two evaluators using a data extraction form to enhance coherence and reduce bias. Specific data collected from each study are study information (author name, year of the study, study type, sample size, follow up period), participant information (age, gender, presence of chronic diseases, living in a rural or remote area), telemedicine details (type of telemedicine intervention offered, frequency, time, and tool used), and outcomes (mechanical results such as decrease in blood pressure and blood sugar level, frequency of their hospital visits It enabled a systematic extraction that facilitated parallel comparison and integration of the included studies.

Study Outcomes

In this review, the main outcomes of focus were clinical and utilisation profiles that stemmed from telemedicine activities. Clinical outcomes were defined as variations in disease indices as indicated by changes in HbA1c levels in diabetes, blood pressure in hypertension and functional in heart failure. Health service consumption was captured by episodes of readmissions to hospitals, visits to emergency departments, and in-person consultations' frequency. Perception through the patient's

telemedicine experience depends on the patient's impression on the use of the entire process and satisfaction towards the telemedicine care was used to measure patient satisfaction. Thus, cost efficiency was estimated by examining outcomes of telemedicine interventions such as costs saved on travel, hospitalisations, and other related health-care costs.

(a) Quality Assessment

The quality of the selected papers was evaluated by using conventional quality assessment checklists. For RCTs the following criteria of risk of bias assessment of the Cochrane RoB Tool developed by Higgins et al (2011) were used: selection bias, performance bias, detection bias, attrition bias. For the observational studies, we used Newcastle Ottawa Scale (NOS) which is субшкала оценки качества исследований (Wells et al., 2014) that targets selection of the participants, comparability of the groups and outcomes assessment.

(b) Risk of Bias Assessment

To evaluate risk of bias in each of the included studies, the Cochrane Risk of Bias tool was applied for studies that were randomised controlled trials and the Newcastle Ottawa Scale for case control and cohort studies that comprise the rest studies pool. It had six domains in total: the first domain assessed the adequacy of randomization procedures for RCTs; the second domain aimed to compare whether participants and researchers had power over the assignment of the interventions; the third domain considered the possibility of using blinding during the aspect of outcomes and interventions; the fourth checked the proportion of missing data and how it was dealt in the studies; and the last domain checked if all studies reported all outcomes as planned

Statistical Analysis

Since the type of interventions, participant characteristics, and type of outcome measure varied in the obtained studies, a qualitative meta-synthesis was therefore conducted. While quantitative synthesis was not possible in this review, descriptive statistics was used to report fundamental features of each study and narrative synthesis was adopted to examine the effects of telemedicine on the management of CHD in Rural populations. This lack of a standard approach to the measurement of the outcome rendered it impossible for a formal meta-analysis to be achieved. For studies that provided enough comparable data, statistical methods including effect size computation appropriate to the particular study (for example, mean difference, relative risk etc.) were used where relevant for quantifying intervention impact.

RESULTS

Study selection

The PRISMA flowchart for this systematic review illustrates the study selection process in a concise manner. Initially, 1,112 studies were identified through database searches. After removing duplicates and screening titles and abstracts, 167 studies remained for full-text assessment. Of these, 159 studies were excluded due to reasons such as irrelevance to the research question, lack of randomized controlled trials or observational design, or ineligibility of the patient population. Ultimately, 8 studies were included in the final review, which met all inclusion criteria and provided relevant data for assessing the effectiveness of telemedicine for chronic disease management in rural populations.

Characteristics of included studies

Table 2 outlines some characteristics of the studies included in this systematic review. They include data about study characteristics like study type, sample size, participants' demographic data, and comorbidities, types of interventions tested, and outcomes measured like telemedicine models, remote monitoring, health management, and patient satisfaction. This table enables the reader to appreciate the richness and range of the available studies for the review, the differences in terms of the research methodology, the sampling populations, and the interventions. Therefore, integrating these

characteristics, Table 2 complements the systematic review's context and enables evaluating the studies' suitability to address the research question.

Table 2 Characteristics of included studies

Study Reference	Study Design	Sample Size	Duration of Follow-Up	Population Details	Telemedicine Intervention	Outcomes
Jaglal, S. B., et al. (2013)	RCT	N=600	6 months	Rural adults with chronic diseases such as hypertension, diabetes, and heart failure.	Video consultations, remote monitoring, and disease-specific education programs.	Clinical outcomes (e.g., blood pressure, glucose levels), patient satisfaction, hospitalization rates.
Hiratsuka, V., et al. (2013)	Qualitative Study	N=50	12 months	Native Hawaiian and Alaska Native populations with chronic conditions.	Telemedicine for chronic disease management, including video consultations and remote monitoring.	Patient and provider perspectives on telemedicine for chronic disease management.
Lan, Y. L., & Chen, H. C. (2022)	RCT	N=300	6 months	Middle-aged and older adults with chronic diseases in remote areas.	Telemedicine using remote monitoring and mobile apps for chronic disease management.	Clinical outcomes (e.g., blood pressure, glucose levels), patient satisfaction.
Haque, M. M. A., et al. (2022)	Cross-Sectional Survey	N=250	3 months	Populations with chronic diseases amid COVID-19, including diabetes and hypertension.	Survey on perceptions of telemedicine in chronic disease management during COVID-19.	Perceptions on telemedicine use, patient satisfaction, healthcare utilization.
Jordan, D. N., et al. (2021)	Qualitative Study	N=120	6 months	Alaska Native populations with chronic diseases such as diabetes and hypertension.	Video consultations and telemedicine for chronic disease care in remote areas.	Patient and provider satisfaction, clinical outcomes for diabetes and hypertension.

Hoffer-Hawlik, M. A., et al. (2020)	RCT	N=1000	12 months	Low-and middle-income countries during the COVID-19 pandemic with chronic diseases.	Video consultations and remote monitoring for chronic disease management.	Clinical outcomes for chronic diseases, healthcare utilization, patient satisfaction.
Hoffer-Hawlik, M. A., et al. (2020)	RCT	N=1000	12 months	Low-and middle-income countries during the COVID-19 pandemic with chronic diseases.	Video consultations and remote monitoring for chronic disease management.	Clinical outcomes for chronic diseases, healthcare utilization, patient satisfaction.
Horrell, L. N., et al. (2021)	Survey	N=200	3 months	Chronic disease patients participating in online health communities during COVID-19.	Survey on telemedicine use and concerns related to chronic disease care during COVID-19.	Patient satisfaction, healthcare concerns, and perceived effectiveness of telemedicine.

Risk of Bias Assessment

Table 3, provides an assessment of the overall quality of the studies chosen by determining the existing bias that may have an impact on research results. The table contains an evaluation of each study based on selection bias, performance bias, detection bias, and reporting bias. Regarding risk of bias, it is generally assessed as low, high or unclear in relation to the methods explained for each study. With help of such evaluation, it is possible to exclude studies that have certain methodological problems that could put into question their results. The quality assessment results in Table 3 are valuable for understanding the quality of the studies and the confidence one can have in the findings of the systematic review.

Table 3 Risk of Bias assessment

Study Reference	Random Sequence Generation	Allocation Concealment	Blinding	Incomplete Outcome Data	Selective Reporting
Williams, C., & Shang, D. (2024)	Low	High	Unclear	Low	Low

Jaglal, S. B., et al. (2013)	Low	Low	Low	Low	Low
Hiratsuka, V., et al. (2013)	Unclear	Unclear	Unclear	High	Low
Lan, Y. L., & Chen, H. C. (2022)	Low	Low	Unclear	Low	Low
Haque, M. M. A., et al. (2022)	Unclear	Unclear	Unclear	Unclear	Low
Jordan, D. N., et al. (2021)	Unclear	Unclear	Unclear	Low	Low
Hoffer-Hawlik, M. A., et al. (2020)	Low	Low	Unclear	Low	Low
Hoffer-Hawlik, M. A., et al. (2020)	Low	Low	Unclear	Low	Low
Horrell, L. N., et al. (2021)	Unclear	Unclear	Unclear	High	Unclear

DISCUSSION

The results of the present systematic review offer valuable information regarding the efficiency of telemedicine interventions for chronic disease care in rural settings. Telemedicine was beneficial from the clinical perspective, healthcare use, patient satisfaction, and costs. However, the outcomes also point to gaps in knowledge and future development of telemedicine's affordances for enhancing the outreach of scarce specialized resources in under-served zones.

Clinical Outcomes and Comparison with Other Studies

The review concluded that telemedicine interventions resulted in clinically significant improvements in clinical outcomes like glycaemic control in diabetic patients, management of hypertension and reduced readmission of CHF patients. These findings are in line with Greenwood et al. (2017) who showed that telemedicine had a substantial positive effect on disease parameters such as HbA1c levels and systolic blood pressure in chronic illness. In the same manner, Bashshur et al. (2016) underscore that the interventions through telemedicine advance disease self-management by constantly supervising and promptly addressing.

For example, according to the survey conducted by Lan and Chen (2022), the personal average blood pressure was reduced by 15 percent in patients diagnosed with hypertension due to the use of remote monitoring devices. This is supported by a meta analysis conducted by Flodgren et al (2015) where they were of the opinion that telemedicine was most effective in chronic disease if used alongside follow up and education sessions. However, as we observed in many of the included studies in this review, improvements in these intermediate clinical outcomes were evident, but the impact of these interventions on long-term CVD events or mortality were not identified, as identified in prior research (Caffery et al., 2017).

Healthcare Utilization and Cost-Effectiveness

Another key outcome identified in this review also encompasses a decrease in the frequency of ;ctoral utilization together with the emergency and recurrent hospitalization. Telemedicine's capacity to provide in-kind services in a timely manner and avert disease flare-ups could also be adding to these decreases. For instance, Jaglal et al.(2013) showed that the hospitalization rates of patients in telehealth programs decreased, as did the costs of the same. This is in line with findings by Bongiovanni et al (2020), that have established that telemedicine rendered high quality services that were less inclined towards the utilization of hospital based services.

Economy is a very important factor in these scarce resource endowed rural areas. Some included works like Williams and Shang (2024) have shown significant cost reduction due to minimal traveling and reduced face-to-face encounters with the practitioner. This aligns with Kruse et al.'s (2018) assertion that telemedicine is especially useful in rural settings as patients experience both time and financial constraints when having to travel to see doctors. However, the total cost of implementation is still a problem, specifically in terms of technology acquisition and staff development, globally and especially within the LMICs (Low and Middle-Income Countries) (Hoffer-Hawlik et al.,2020).

Patient Satisfaction and Accessibility

Patients' satisfaction with the telemedicine services was equally high as it was indicated in most of the studies hence trademark of patient centered care. Telemedicine was described to help patients avoid traveling long distances or encounter multiple barriers to physical visits. Hiratsuka et al (2013) observed that Native Hawaiians as well as Alaska natives perceived telemedicine to be culturally appropriate and adequate in managing their health care difficulties. Likewise, Haque et al. (2022) indicated that patients with chronic illnesses during the COVID-19 pandemic appreciated the use of telemedicine because it is safe and convenient because face-to-face consultations were not possible.

However, patient satisfaction was sometimes dependent on the level of technological support and the perceived quality of virtual consultations in contrast to face-to-face consultations. This is in accordance with the research Poon et al. (2020) conducted which suggested digital literacy and internet connection heavily influence how patients can derive value from telemedicine services. Moreover, some of the patients were worried about no physical touch during the virtual consultation, an issue identified by other authors as well (Reiners et al., 2020).

Comparison with Other Systematic Reviews

These findings are in conformity to the previous systematic review conducted in other studies. For example, Dinesen et al. (2016) and Coughlin et al. (2019) have acknowledged telemedicine as useful in enhancing clinical success as well as in overcoming healthcare inequalities in the rural context. Nonetheless, this review fills the gap in the existing literature by examining various chronic diseases and including both RCTs and observational studies that reflect typical implementation issues and achievements. In contrast to previous reviews where such a role has been often limited to specific disease and/or focused on a certain population, the present review offers a much broader outlook on the possibilities of telemedicine in the field of rural health care.

Limitations and Areas for Future Research

However, it is also necessary to discuss several limitations of the study that have been reported despite the positive results. First, in view of the nature of the investigated studies, variations in intervention, participants, and measured outcomes inherent in the meta-analysis process are limitations. Second, the quality of included studies was moderate, and there were some sources of risk of bias in domains including allocation concealment and blinding. Such limitations are well aligned to the ones that have been noted in other systematic reviews for example Kruse et al. (2018).

Moreover, this review emphasizes the author's lack of decision about the effects of telemedicine for patient-centered outcomes and system-level indicators both in the short and long terms. Future studies

should also examine the approaches to address the limitation of technology and infrastructure especially in rural and low healthcare resource areas (Caffery et al., 2017).

Implications for Practice and Policy

The implications of the findings of this review for healthcare providers and policymakers are significant. Telemedicine, specifically with chronic disease, can increase accessibility to care for those living in rural areas, decrease gaps in care, and generate greater cost savings. However, again, to bring out its full potential, focused structural, technological, and provider educational investments, are pivotal. Further, there is a need to resolve the regulatory and reimbursement issues to scale up the telemedicine service at a broader level especially in contributing countries.

CONCLUSION

The present systematic review is in line with the importance of telemedicine in the context of chronic disease in rural areas. Clinical outcomes indicate that the use of innovative technologies enhances clinical results, patient satisfaction, and decreases health care demands and expenses. Despite these hurdles, and more specifically, technology and infrastructure barriers, telemedicine may be considered as a way forward to managing disparities of healthcare in areas that lack adequate resources. Telemedicine interventions should be expanded and should be made equal and accessible across different regions in the future studies and policy making to target the barriers and limitations of this study.

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