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Research Article

Telemedicine and Use of Remote Monitoring in Cardiovascular Disease: A Systematic Review

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Abstract

Background: With the high prevalence of cardiovascular disease (CVD) across the globe, telehealth offers great potential for the management of rehabilitation and primary prevention. Lifestyle changes are also known to contribute to primary and secondary prevention strongly.

Aim: This study aimed to assess the effectiveness of telehealth intervention in the primary and secondary management of CVD.

Method: The systematic review was performed as per the Cochrane methods. We searched relevant databases between 2010 and 2021. We chose studies as per the inclusion criteria and used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guideline.

Results: Twenty randomized controlled trials met the inclusion criteria. We used different telehealth methods with monitoring, including telephone calls, text messages, emails, online platforms, and remote monitoring of physiological parameters. Compared to routine care, we found moderate evidence of telehealth intervention efficacy.

Conclusion: Our findings demonstrate positive outcomes for primary and secondary prevention of CVD. Telehealth can be incorporated as part of routine care to prevent and manage CVD.

Keywords: Telemedicine; Remote Monitoring; Cardiovascular Disease; Access; Healthcare

1. Introduction

Telemedicine has been reintroduced within the modern era following the recent coronavirus disease 2019 (COVID-19) pandemic [1]. However, the concept of telemedicine was first introduced in the early 20th century, focusing on the transmission of images [2]. Over time, telemedicine was also being incorporated in remote patient monitoring. In the last two decades, there has been great progress with the simultaneous use of smartphone and broadband advances and capabilities [3]. The current healthcare model is presented with challenges to access healthcare by patients. The COVID-19 pandemic has resulted in a rapid shift in the healthcare delivery model with the adoption of telemedicine [4]. During the pandemic's peak, we adopted remote consultation and monitoring to support traditional face-to-face consultations between patients and healthcare workers [5]. Incorporating telemedicine within healthcare was not limited to high-income countries (HICs) but was also present in low- and middle-income countries (LMICs) [6]. Specifically considering cardiovascular disease (CVD), we can easily monitor patients for their vitals and symptomatology remotely [7]. Typically, these telehealth technologies contain wearables such as watches or patches, which can prevent severe complications [8]. The following review focuses on the currently available data within the telemedicine technologies for CVD patients as preventive or interventional modalities. With the combined empirical evidence, we aim to integrate further and develop telemedicine-based healthcare in CVD patient care.

2. Methods

2.1 Search strategy and selection

We reviewed the following databases, including MEDLINE, Clinical Key, and Cochrane Library. Two reviewers screened the records. The first step was to examine the title and abstract, followed by

full-text reviews. The third reviewer addressed discrepancies between the first two reviewers during every stage of the selection process. We selected only articles in English. There was no restriction on the search strategy. We included all articles from 2010 until November 24, 2021. The keywords including "cardiovascular disease, "CVD," "remote monitoring," and "telemedicine" were included. We included only relevant randomized controlled trials (RCTs). Further, a review of the reference list was also conducted of relevant articles as part of an umbrella review to ensure the inclusion of all relevant articles. Duplicates were removed using the software Endnote X9.

2.2 Objectives

The primary objective is to demarcate current evidence available for remote monitoring of patients with CVD. The secondary aim is to explore the feasibility of incorporating remote monitoring as part of the healthcare delivery model at a large scale.

2.3 Data analysis

Following the study inclusion, the studies were first assessed for quality. All three reviewers utilized the Newcastle-Ottawa Scale (NOS). Three reviewers extracted data on a customized datasheet in Excel. The following variables were tabulated for the included RCTs: author-year, country, target condition, number of participants, proposed benefit, specific use of telemonitoring, and advantage. We conducted the qualitative analysis to identify currently available evidence regarding remote monitoring technologies for CVD patients.

3. Results

The search process is shown in Figure 1. The first phase of the screening yielded 316 results. After removing duplicates, we reviewed 310 results for titles and abstracts. In the second phase, we excluded 213 results as they did not meet the eligibility criteria. Twenty studies were finalized and included in the qualitative analysis during the third phase.

In total, six studies reported outcomes focusing on reducing all-cause readmission or all-cause mortality with telehealth interventions among patients with chronic heart failure (CHF). Among these trials, Gallagher et al. [9] did not identify any beneficial outcomes when focusing on adherence to medication with telephonic support. The other five trials identified a reduction in all-cause readmission and all-cause mortality with telehealth enabled intervenetions, including self-care behavior with short messages [10], monitoring of pulmonary artery pressure with a wireless hemodynamic monitoring system [11], electronic documenting of vitals [12], combined monitoring of the electrocardiogram, blood pressure, body weight, and oxygen saturation (SpO_2) [13], communication about symptoms [14], and home-based exercise program [15].

Investigators from one trial reported all-cause readmission or mortality following percutaneous coronary intervention (PCI) for acute coronary syndrome (ACS). Investigators from another trial collected exercise and dietary habits of participants over online and smartphone platforms but that did not show any significant reduction in all-cause readmissions or mortality [16]. The second trial monitored dietary and exercise habits similarly and reported weight loss after telehealth monitoring [16]. Eleven trials supported self-rehabilitation following primary diagnosis of CVD through sending text messages [17, 18], online platforms [19-21], telephone calls [22-

25], and remote monitoring [26]. Two trials monitored primary prevention of CVD with telephone calls [27], emails [27], online platforms [27, 28]. Overall, the studies conducted telehealth interventions and monitoring by sending text messages, telephone calls, telephone calls combined with messages, online programs, emails, and telemonitoring. The major characteristics are summarized in Table 1.

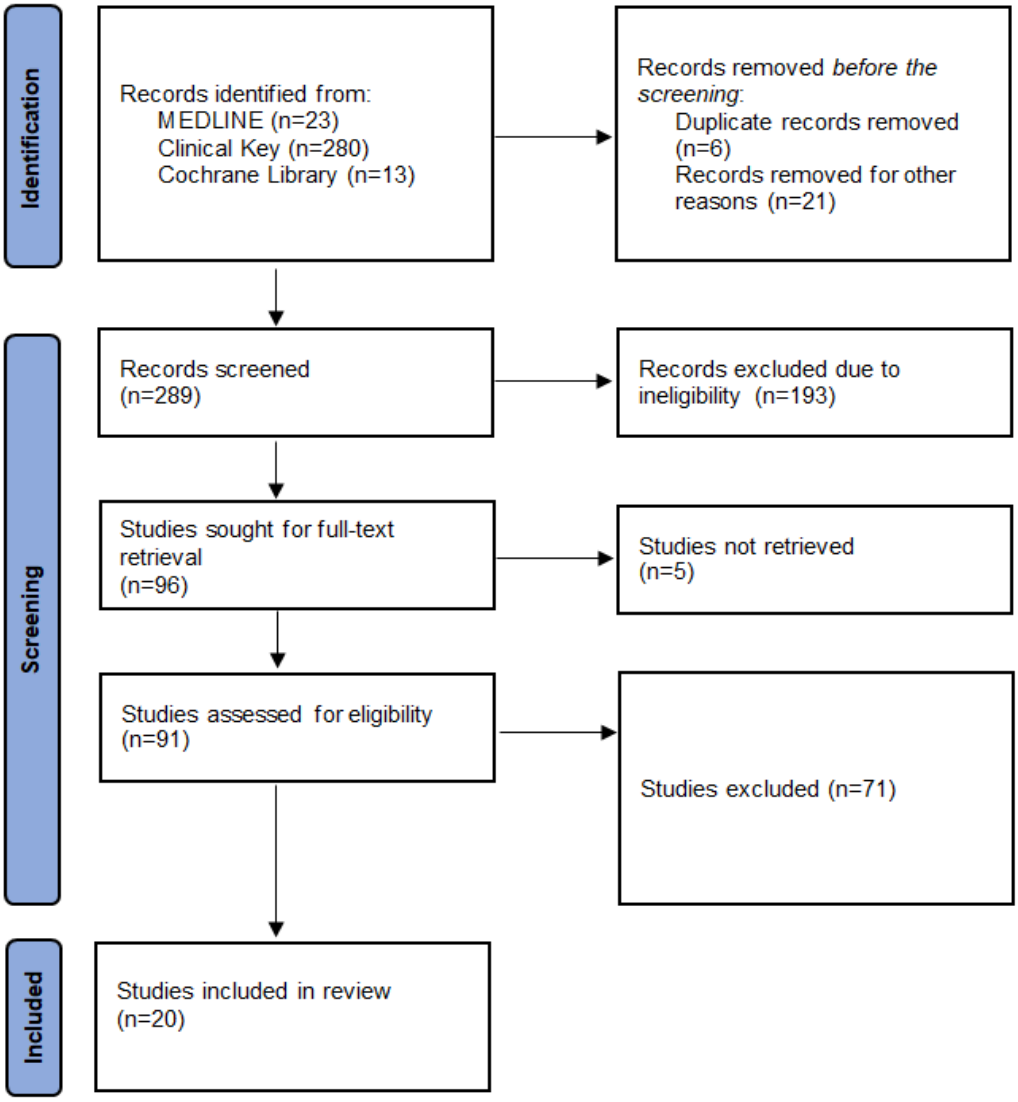

Figure 1: PRISMA Flowchart for selection of studies.

Author-year	Country	Target condition	Number of participants	Proposed benefit	Specific use of tele-monitoring	Advantage
Gallagher-2017 (9)	USA	CHF	40	Reduction in readmission	Adherence to medication with telephonic support	No improvement in adherence compared to passive monitoring group patients
Chen-2019 (10)	China	CHF	767	Better self-care behavior for reduction in all-cause mortality or readmission	Short message service or structured tele-phone support	Effective reduction of all-cause mortality or readmission
Abraham-2011 (11)	USA	CHF	550	Reduction in readmis-sion	Measurement of pulmonary artery pressure with a wireless implantable hemo-dynamic monitoring (W-IHM) system	Significant reduction in readmission
Reid-2012 (29)	Canada	CHD	223	Improvement in rehabi-litation	CardioFit internet-based physical activity expert system with online coaching	Improvement in objective and self-reported physical activity as well as the self-reported emotional and physical quality of life
Dendale-2012 (12)	Belgium	CHF	160	Reduction in readmis-sion and all-cause morta-lity	Electronic device documenting body weight, blood pressure, and heart rate daily on an online database	Reduction in readmission and all-cause mortality
Koehler-2018 (13)	Germany	CHF	1571	Detection of early symptoms and reduction in readmission and all-cause mortality	A multicomponent system with daily monitoring using a three-channel electro-cardiogram (ECG) device to collect either a 2 min or streaming ECG measurements, a blood pressure measuring device and weighing scales as well as SpO_2	Reduction in readmission and all-cause mortality
Widmer-2017 (16)	USA	ACS	64	Reduction in ER visits and readmission after PCI	Online and smartphone-based CR platform obtaining patient dietary and exercise habits	No significant reduction in ER visits and readmissions but improved weight loss

Boyne-2012 (14)	Netherlands	CHF	870	Reduction in readmission	A device with a liquid crystal display and four keys connected to a landline phone with communication about symptoms, knowledge, and behavior	No significant difference in reduction of readmission compared to in-person follow-up
Vernooij-2012 (19)	Netherlands	CVD	330	Secondary prevention of CVD through improvement in risk factor management	Personalized website of the actual status of patients' risk factors system	Small effect on vascular risk reduction
Appel-2011 (28)	USA	CVD	415	Primary prevention through enhancement in weight loss	Remote support through telephone, a study-specific Web site, and email	No significant difference in weight loss compared to in-person support
Heron-2019 (22)	UK	CVD	40	Prevention of secondary TIA	Telephonic follow-up for the education of stroke risk factors	Acceptable intervention for secondary prevention of TIA
Bosworth-2018 (23)	USA	CVD	429	Prevention of primary CVD	Telephone-based education for self-management of risk factors of CVD	No significant long-term improvements in risk for CVD
Coorey-2020 (27)	Australia	CVD	934	Prevention of CVD	E-health enabled positive health behavior integrated with primary EHRs	Positive reinforcement for reduction of modifiable risk factors when combining primary EHRs with e-health education
Chow-2015 (18)	Australia	CVD	710	Prevention of CVD	Text message focused on reduction of secondary CHD	Lifestyle-focused text messaging improved LDL-C level and risk factors of CVD
Dale-2015 (20)	New Zealand	CHD	123	Prevention of secondary complications of CHD	Mobile-delivered comprehensive cardiac rehabilitation to improve adherence to lifestyle behaviors	Positive effect on adhe-rence to lifestyle behavior changes
Peng-2018 (15)	China	CHF	98	Prevention of secondary complications of HF	Home-based exercise via telehealth	Telehealth exercise training is effective similar to cardiac rehabilitation

Hawkes-2013 (24)	Australia	CHD	337	Prevention of secondary complications of MI	Telephone-delivered secondary prevention of CHD	Improvement of health-related quality of life with telephone-delivered education
Johnston-2016 (21)	Sweden	MI	174	Prevention of secondary MI	Smartphone support application focusing on drug adherence and lifestyle changes	Interactive patient support tool resulted in self-reported drug adherence and lifestyle change improvement
Yan-2014 (25)	China	MI	124	Prevention of secondary MI	Telephone-based follow-up after MI for improving perception and lifestyle	Significant improvement in illness and lifestyle after MI
Widmer-2017 (16)	USA	ACS	80	Cardiac rehabilitation following ACS	Digital health intervention with an online and smartphone-based platform to report dietary and exercise habits	Improvement in weight loss with complementary digital health inter-ventions
Karhula-2015 (26)	Finland	CVD	517	Quality of life impro-vement with concurrent diabetes	Self-monitoring of weight, blood pressure, blood glucose, and steps once per week for remote monitoring	No improvement in the quality of life or clinical conditions

ACS: Acute coronary syndrome; CVD: Cardiovascular disease; CHF: Chronic heart failure; CHD: Coronary heart disease; EHR: Electronic health record; ER: Emergency room; HF: Heart failure; LDL-C: low-density lipoprotein cholesterol; MI: Myocardial infarction; RCT: Randomized control trial; USA: United States of America.

Table 1: Summary of key findings of the included RCTs for telemonitoring in CVD management.

4. Discussion

This review summarizes data from 20 RCTs published in 2010-2020 reporting telehealth within CVD prevention and management. We aimed to examine the effects of telehealth compared to routine care for either primary or secondary prevention of CVD. In the qualitative analysis, we found efficacy with telehealth interventions focusing on secondary prevention. The present study's findings can be generalized as the data is obtained from RCTs globally. We noted that control of risk factors remains challenging with telehealth interventions, with certain studies reporting improvement compared to current standards of care. There may be various reasons that render telehealth interventions suboptimal. For instance, lifestyle changes are difficult to incorporate due to the lifelong fostering of these habits. Studies in our review show that telehealth interventions that focus on remote monitoring also offer some efficacy. However, we expect certain trials to perform better than others, probably due to differences in baseline characteristics.

CVD is the leading cause of mortality across the United States [30]. With the change in demographic patterns across industrialized nations, we may expect a higher burden of patients with CVD and its complications [31]. It is expected that by 2030, the prevalence of CVD is expected to increase rapidly. With the recent popularity of telehealth, it is pertinent to optimize telehealth interventions and monitoring for CVD [32]. Mobile applications are present within platforms that may collect information about patient physiological metrics, symptomatology, and disease education [33]. The collection of physiological data may also be present through smartphones. Recently, wearable devices have gained popularity as they may detect arrhythmias and act as portable sensors (e.g., Apple Watch) [33]. Other sensors may also detect heart rate, ECGs, and blood pressures. These technologies are present in industrialized nations and across developing nations such as India [34].

Another target for cardiac rehabilitation in heart failure patients is medication adherence [35]. While our study did not find any major improvement in medication adherence, it is an important target for cardiac telemonitoring. This could be particularly beneficial for older populations. There are numerous opportunities for streamlining programs that focus on singular outcomes such as patient education, self-monitoring, improving physical health, which falls within the arena of self-management [36]. Other aspects of telehealth include remote monitoring, which provides concrete information about patients with CVD [37]. We suggest further RCTs that focus on examining personal determinants of health, with aim to improve cardiac rehabilitation and prevention of CVD. Our study has a few limitations. There were differences in the outcomes of the studies that were included. Therefore, it was difficult to ascertain the objective benefits of each type of telehealth monitoring employed. We also did not find any clear follow-up period across the trials. Therefore, it was not possible to confirm whether the trials that had shown efficacy would also result in long-term improvement in the health status of the participants.

5. Conclusion

We found moderate-grade evidence of the beneficial effects of telehealth monitoring among CVD patients. Modifiying the lifestyle and habits of the participants was challenging, in both primary and secondary prevention of CVD. We expect telehealth to improve

and widen the scope of cardiac monitoring and rehabilitation in the next few decades. With numerous trials underway for the management of CVD, patients may benefit from telehealth monitoring of their health status. Remote contact with healthcare providers also provides an assessment of functional capacity, attainment of cardiac rehabilitation, and potential of readmission to hospitals. These ongoing trials are important as they will develop the current understanding of cardiac telehealth and improve the existing burden.

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