Original Article

Effectiveness of telemedicine for cardiovascular disease management: systematic review and meta-analysis

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Background: With the development of information communication technology (ICT), telemedicine has become a promising option for patients with chronic diseases who need continuous monitoring at home or in remote health care facilities. As cardiovascular disease (CVD) is responsible for an estimated 17.9 million deaths globally each year, it is appropriate to evaluate the effectiveness of telemedicine for the health care management of CVD patients.

Methods: The Library of Congress, LISTA (EBSCO), PubMed (NLM), and Web of Science databases were searched with a date limitation from 1 January 2000 until 5 August 2021 for Randomized Controlled Trial (RCT) studies. Two independent researchers screened the records for inclusion and extracted the data for synthesis, supported by RevMan 5.0 software. As one of the clinical outcomes, the mean difference and standard deviation of systolic blood pressure were synthesized. For the Quality-of-life measures, EuroQol-5D (EQ-5D) scores were also synthesized and for the depression level, CESD-10 scores were synthesized.

Results: We identified 23 studies for qualitative analysis and 21 studies for quantitative analysis. 21 studies included systolic blood pressure as an outcome measure and the results show a statistical difference ($P<0.05$) between the intervention group and the control group and a favorable inclination toward the Telemedicine enhanced health care program over the usual care. Of the six studies that included body mass index (BMI) as an outcome measure, there was no significant difference in BMI between the telemedicine and usual health care groups. A total of five studies assessed patients' quality of life using the EQ-5D instrument. After excluding one study following the sensitivity analysis, telemedicine was shown to significantly improve patients' quality of life. Three studies that investigated patients' mental health (CSE-D-10) also showed a significantly beneficial effect of telemedicine over usual health care.

Discussion: This review found limited evidence to support some of the outcomes in the original study designs. Overall, our findings suggested a favorable effect of telemedicine intervention in the field of health care for CVD patients. Due to the unavoidable heterogeneity within the selected literature, a more detailed investigation and analysis of the unclear outcomes is recommended.

Keywords: Telemedicine; cardiovascular disease (CVD); health management

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Introduction

Cardiovascular disease (CVD) is one of the major diseases that seriously threaten human health and life. The average prevalence of cardiovascular disease is one in the world, and the trend is increasing year by year. Statistics show that about 1/3 of the deaths in the world are caused by cardiovascular diseases, which shows that the prevention and diagnosis of cardiovascular diseases are of great significance. Entering the 21st century, the world has seen an important development in the field of information communication technology (ICT), which offers novel opportunities to various industries. With the advancement in sensing technologies, a variety of remote patient monitoring (RPM) (1) solutions are available with a precise ability to collect physiological data compatible with hospital medical equipment. In 2005, Qilu Hospital of Shandong University established the first "Remote mobile Monitoring Center for out-of-hospital heart" in Asia. The heart of the remote mobile monitoring system *in vitro* via heart dirty monitoring in hospital according to the processing platform (cardiac remote monitoring Care center) with CVD patients carry phone connection, the center can through the remote mobile monitoring data of the patients with continuous system the real-time analysis, recording, monitoring data sending and receiving the doctor's orders information, etc. In addition to mobile devices such as mobile phones, the center can also use landlines to send electrocardiogram (ECG) monitoring data related to cardiovascular patients. These innovations, along with artificial intelligence (AI) and other assistive technologies for data processing and analysis, make it possible to conduct at-home health care programs for chronic disease patients rather than requiring them to be admitted to hospital. The present study involves a systematic review of telemedicine health management for CVD patients.

This review focuses on the health care of older adults. In a traditional health care program, a physician or a qualified health care professional needs to visit the patient every 2–3 hours based on the patient's condition, which has a considerable medical cost. The advantage of telemedicine is that it can remotely monitor the patient's vital signs while sending data to a doctor or pharmacist who can change the prescription or dosage accordingly. In addition, fewer hospitalizations result in proportionally reduced medical costs and allow patients more free time, which may contribute to their quality of life (QoL) or mental health.

The World Health Organization (WHO) defines telemedicine as "*The delivery of healthcare services, where distance is a critical factor, by all healthcare professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation and for the continuing education of healthcare providers, all in the interests of advancing the health of individuals and their communities*".

In this particular domain of health care, telemedicine technology can improve cardiovascular diseases through remote consultation, remote monitoring, remote treatment and other technologies, examples of telemedicine applications could involve a portable biometric device connected to the internet, patient monitoring systems using ballistocardiography (2) or seismocardiography (3) sensors, or simply an SMS-based messaging system.

Bashshur *et al.* (4) noted that telemedicine facilitates the population in communities with maldistribution of medical care.

The same authors also acknowledged that development and policy making in regard to telemedicine was limited because of "the lack of a comprehensive research strategy that specifies the objectives of telemedicine research regarding accessibility, cost, and quality". Hence, this study aimed to conduct a comprehensive review of the application of telemedicine to the treatment of CVD. A systematic understanding of this new type of technology allows researchers to obtain empirical evidence regarding the feasibility and the reliability of its promising application.

This study was performed to systematically review the effectiveness of telemedicine for the health care of older adults with CVD. We present the following article in accordance with the PRISMA reporting checklist (5) (available at https://dx.doi.org/10.21037/apm-21-3626).

Methods

Trial protocol

This study has been registered on PROSPERO (ID: CRD42021269581) and protocol could be accessed through this platform.

Criteria for study inclusion

We aimed to include published clinical studies that evaluated the effectiveness of telemedicine-enhanced health care programs for CVD patients. Only randomized controlled trials (RCTs) were included, and the participants

Table 1 Specification for studies to be included

Patient	Intervention/comparison	Outcomes	Study design
(I) Cardiovascular diseases	Telemedicine/usual health care	(I) Life quality	Randomized controlled trial
(II) Elderly/geriatric/senior/ aged/older adults		(II) Medical cost	
		(III) Disease-specific clinical outcomes	
		(VI) Mental health	

Table 2 Search strategy

#1 AND #2	Search strategy
#2	"Cardiovascular disease" OR "hypertension (HTN)" OR "coronary artery disease" OR "congestive heart failure"
#1	"RPM" OR "remote patient monitoring" OR "remote health monitoring" OR "telemonitoring" OR "telemedicine" OR "telehealth" OR "m-health"

RPM, remote patient monitoring.

were all older adults. The primary outcome measures were systolic blood pressure (SBP) and body mass index (BMI), with medical costs, mental health, and quality of life (QoL) as the secondary outcome measures.

Our inclusion criteria stipulated that eligible studies were required to report empirical findings on the association between telemedicine health care and improvements in primary and secondary clinical outcomes. Primary clinical outcomes included variables such as blood pressure, BMI, admission rates, and mortality. Secondary outcomes, such as patients' QoL, medical costs, or depression levels were considered suitable for studies to be included. The detailed inclusion criteria concerning populations, intervention/controls, outcomes, and study designs are shown in *Table 1*.

Search strategy

The Library of Congress, LISTA (EBSCO), PubMed (NLM), and Web of Science Core Collection (TR) databases were searched with a date limitation from 1 January 2000 until 5 August 2021. The search terms used in various combinations were as follows: "RPM", "remote patient monitoring", "remote health monitoring", "telemonitoring", "telemedicine", "telehealth", "m-health", "cardiovascular disease", including "hypertension (HTN)", "coronary artery disease", and "congestive heart failure" based on their high global burden. A comprehensive list of the population types and intervention settings is shown in *Table 2*. The publication language was restricted to English only.

We also conducted a search of dissertation collections from resources within the authors' organizations.

Data collection

References collected from the electronic databases and other resources were organized into an EndNote interface to complete further screening according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (5) flow chart.

Data concerning the first author's name, year of publication, country of publication, trial duration, study design, methodology, participant demographics, and outcomes, including QoL, medical costs, and clinical outcomes, were extracted. Two researchers independently evaluated the title, abstract, and full text of each retrieved article and determined the study's eligibility based on the inclusion and exclusion criteria outlined above. If there was a difference of opinion between the two researchers, a third researcher was consulted to resolve the disagreement.

The extracted data were recorded in Table S1.

Statistical analyses

The extracted data were analyzed by the Review Manager 5.0 software provided by Cochrane Collaboration Network. The dichotomous variables were presented by odds ratio (OR) or risk difference (RD). Continuous variables were expressed by mean difference (MD). Both data were presented using a 95% confidence interval (CI). I^2 value was

used to test the heterogeneity between different studies. When the heterogeneity was significant ($I^2 \geq 50\%$), random-effects model was used for data analysis. On the contrary ($I^2 < 50\%$), a fixed-effects model was used for data analysis. The difference was statistically significant when $P<0.05$.

Assessment of risk-of-bias in the included studies

Since all included studies were RCTs, the risk-of-bias was assessed based on the Jadad scale (6) (a 5-point scale evaluating the quality of RCTs) and the Cochrane risk-of-bias tool (supported by RevMan software).

Data synthesis and analyses

The primary outcomes were absolute changes in SBP and BMI from baseline to follow-up. There is a growing realization that elevated SBP may be a more valuable measurement in evaluating and controlling CVD than is generally acknowledged (7). Additionally, the age-adjusted relative risk (RR) for new hypertension has been shown to be highly associated with overweight status (8) (male: RR 1.46; female: RR 1.75), making BMI a suitable outcome measure for this study.

Secondary outcomes included the absolute change in EuroQol-5D (EQ-5D) scores for QoL and the Center for Epidemiological Studies Depression Scale (CSE-D-10) scores for mental health. They were obtained from the original studies or calculated (differences in arithmetic means at baseline and conclusion of the intervention) (9). When deviation of the mean difference was not available, the authors were contacted. In cases where there was no response or no availability of the requested information, the variance was estimated by using the reported confidence intervals, reported P values, or an imputation using the standard deviation at follow-up in both groups to calculate the standard error of difference. As for medical cost outcomes, the intervention costs, effects [the quality-adjusted life year (QALY) (10)], and incremental cost-effectiveness ratio (ICER) data were extracted, and we applied a qualitative analysis due to its nature.

A random-effects model was used for pooling the included studies, as heterogeneity was expected.

A meta-regression was conducted to identify the origin of the potential heterogeneity (only for the primary outcomes, which were documented in the largest number of studies).

A sensitivity analysis was applied to the secondary outcomes to verify the robustness of the synthesized results.

Results

Search results

A total of 657 references were extracted from the online databases and gray literature according to the Participant, Intervention, Comparison, Outcome and Study design (PICOS) search strategy, which is shown in Table S1. The studies were selected from the following sources: Library of Congress (n=2), EBSCO (n=7), PubMed (n=646), and two additional studies from internal sources.

Two researchers independently conducted the literature searches, and any disagreements were resolved by consultation with a third researcher.

After reading the titles and abstracts, 541 records were excluded for not meeting the inclusion criteria, including animal trials, reviews, case reports, correspondence, meeting abstracts, etc.

The second screening was based on the full text analysis, and 79 studies from the remaining 111 studies were subsequently excluded for not matching PICOS criteria and incomplete data. This process can be seen in *Figure 1*.

Finally, 23 records were selected for the qualitative synthesis (11-33) and 21 for the quantitative synthesis (meta-analysis). The remaining 79 records were excluded for being study protocols, not providing trial data, or not matching the PICOS criteria. The whole screening procedure was supported by EndNote.

Our meta-analysis combined the outcomes of 7,602 cardiovascular patients from 21 individual studies. The distribution of the specific types of CVD is shown in *Figure 2*, with one study including both hypertension and hyperlipidemia.

Effectiveness of telemedicine for primary outcomes

Systolic blood pressure

A total of 21 studies were included in the quantitative meta-analysis of SBP (*Figure 3*). We used a random-effects model since there was significant heterogeneity ($I^2>50$) with the difference in means (baseline, and at study completion) as the effect measure. The results showed a statistical difference ($P<0.05$) between the intervention and control groups with a favorable inclination toward the telemedicine-enhanced health care program over usual care.

Due to the different intervention lengths, we divided the original data set into three sub-groups for further analysis (group 1 = 3 months' duration, group 2 = 6–8 months' duration, and group 3 = 12 months' duration) as shown in

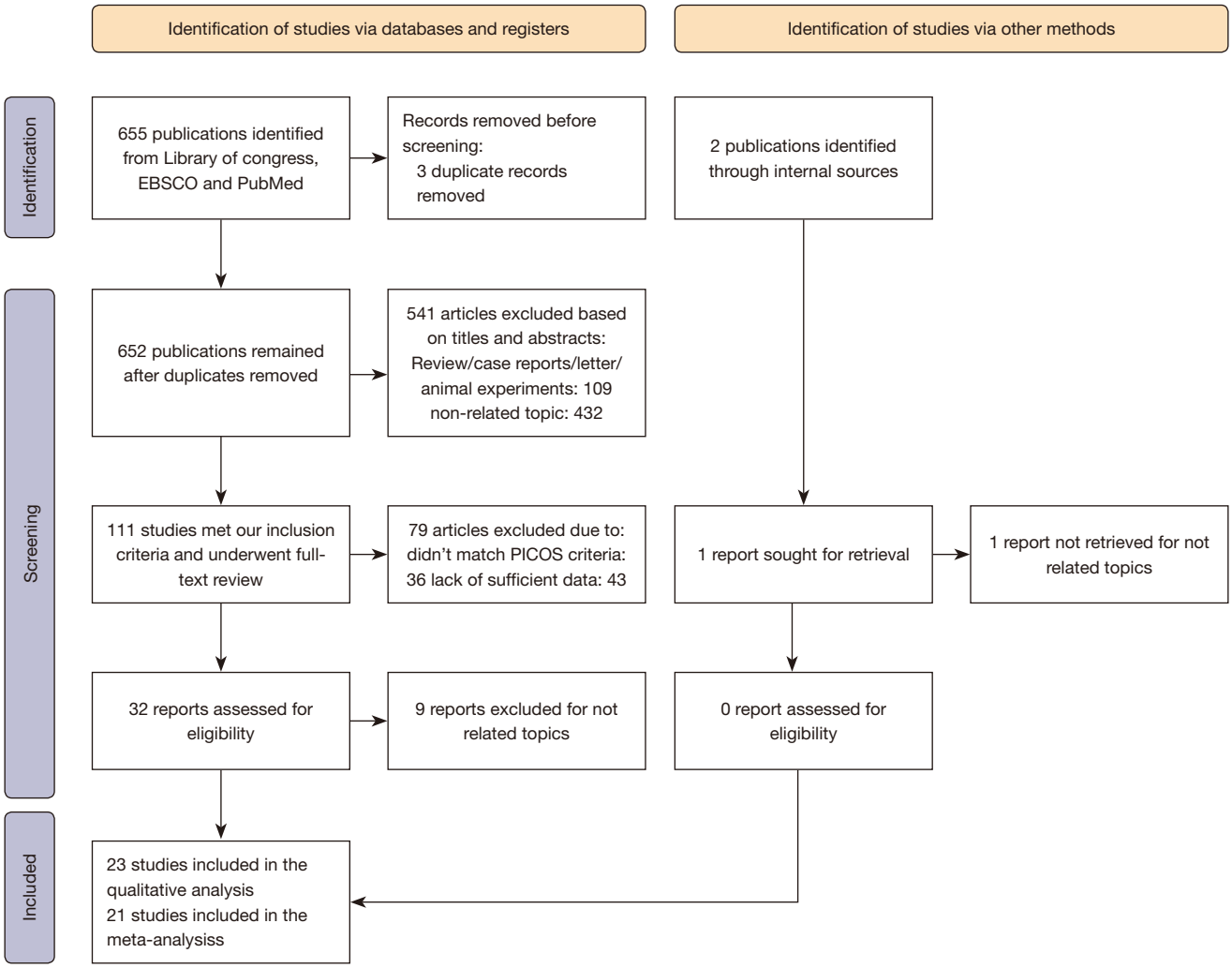

Figure 1 Study flow diagram.

Figure 4.

There was no difference in heterogeneity (I^2>50%) between any of the sub-groups and the original data, and all showed significant differences between the intervention and control groups.

Body mass index

A total of six studies were included for the BMI (34) synthesis (*Figure 5*). There was evident heterogeneity (I^2>50%) and no statistical difference between the intervention and control groups (P>0.05), indicating that the use of telemedicine had no significant effect on patients' body mass index.

Effect of telemedicine on secondary outcomes

Quality-of-life (EQ-5D)

As an extension of ICT, telemedicine-supported health care programs necessarily collect patients' data, but this may be seen as an intrusion of privacy by older adults who are less familiar with information technologies (35). This hypothesis may lead to a poorer quality of life. To evaluate the effect of telemedicine on quality of life, we selected five articles that used the EuroQol 5 Dimension (EQ-5D) (36) scale to assess QoL in terms of mobility, self-care, usual activities, pain/discomfort, and anxiety/depression.

The effect measure was the mean difference. The initial

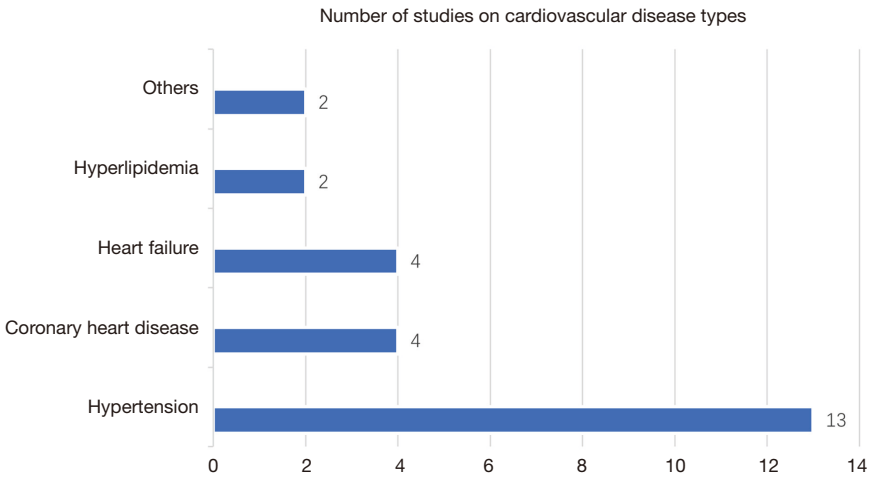

Figure 2 Types of cardiovascular diseases in included studies.

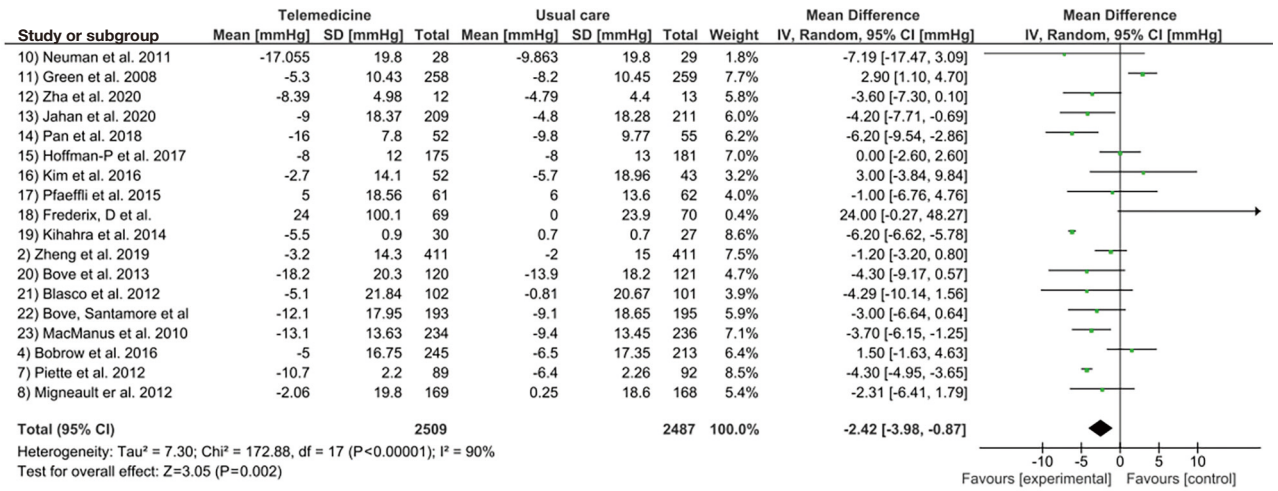

Figure 3 Forest plot for SBP. SBP, systolic blood pressure.

results displayed significant heterogeneity (I^2=100%) and a significant difference (P>0.05), as shown in *Figure 6*. After the sensitivity analysis excluded one study (7), the remaining four studies demonstrated no heterogeneity between them and continued to show a significant difference in QoL (P<0.05) (*Figure 7*).

Mental health (CSE-D-10)

To assess mental health and levels of depression, we selected three studies that used the 10-item CSE-D-10 and analyzed the combined results. The results demonstrated heterogeneity between the studies (I^2>50%) and a significant difference (P<0.05) between the intervention and control groups (*Figure 8*).

Medical cost

Frederix *et al.* (17) conducted an RCT to compare health care cost differences between cardiac telerehabilitation (intervention group) and conventional cardiac rehabilitation (control group). Their results indicated that the intervention group (€2,156±€126) had a significantly lower total average cost per patient than the control group (€2,720±€276) with an overall incremental cost of €–564.40. Dividing this incremental cost by the baseline-adjusted

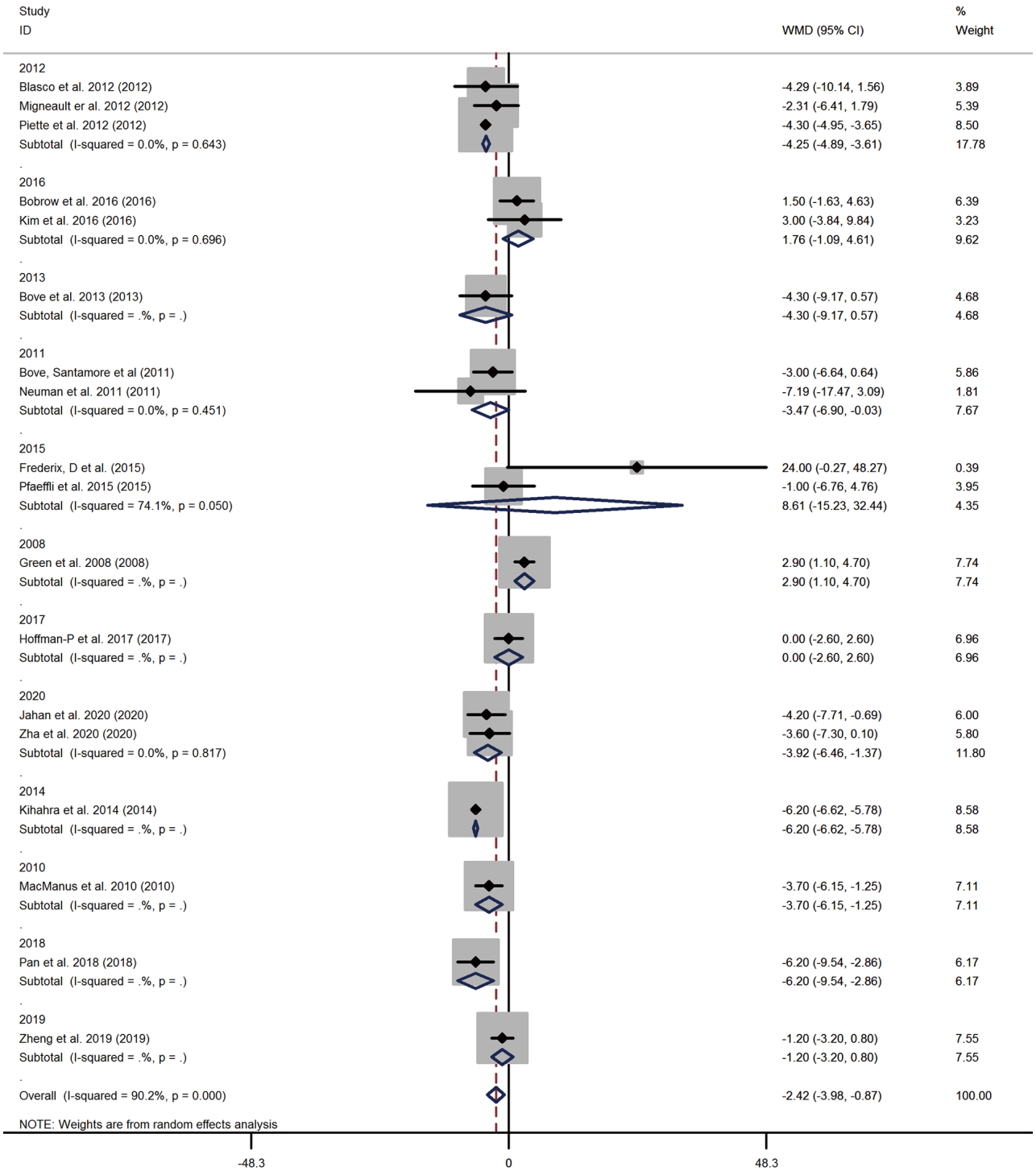

Figure 4 Sub-group analysis of SBP on intervention duration. SBP, systolic blood pressure.

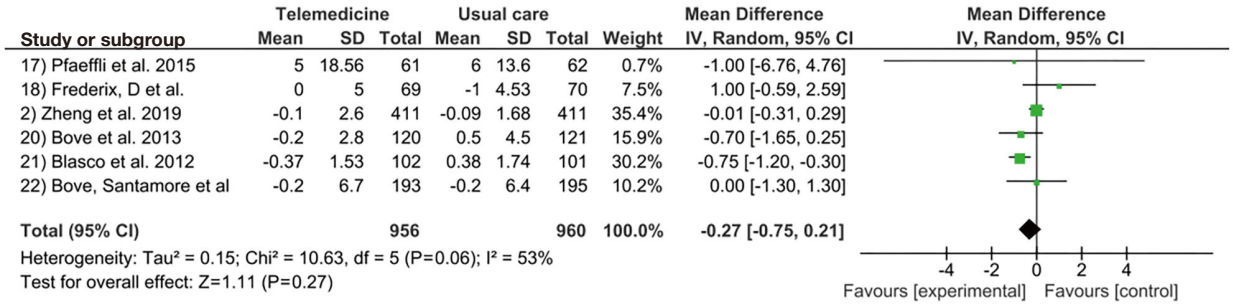

Figure 5 Forest plot for BMI. BMI, body mass index.

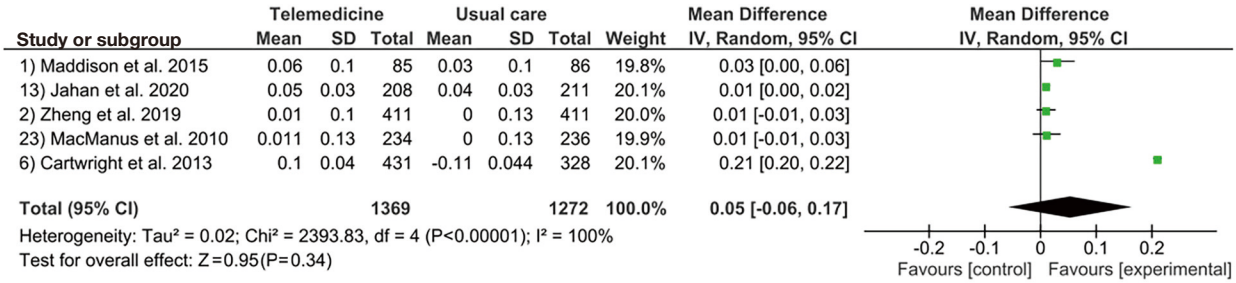

Figure 6 Forest plot for EQ-5D (original).

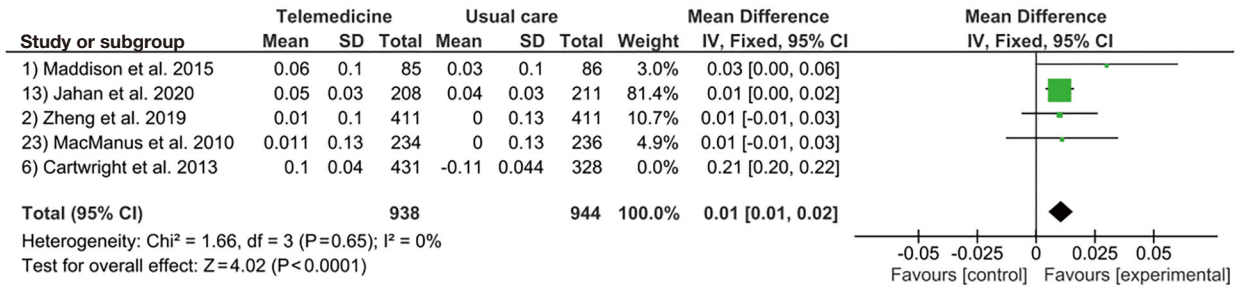

Figure 7 Forest plot for EQ-5D (sensitivity analysis).

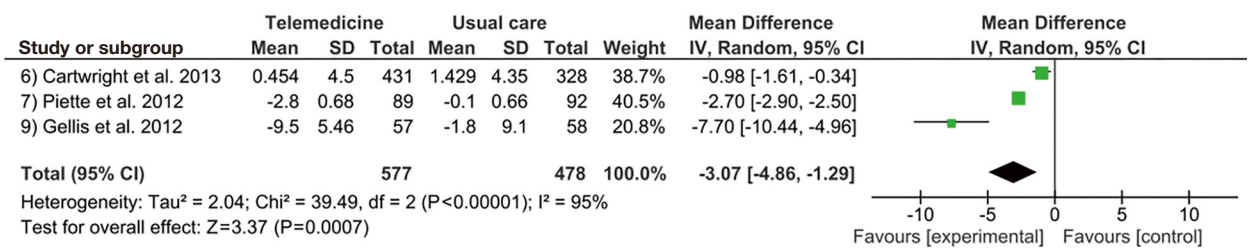

Figure 8 Forest plot for CSE-D-10 (patients' mental health).

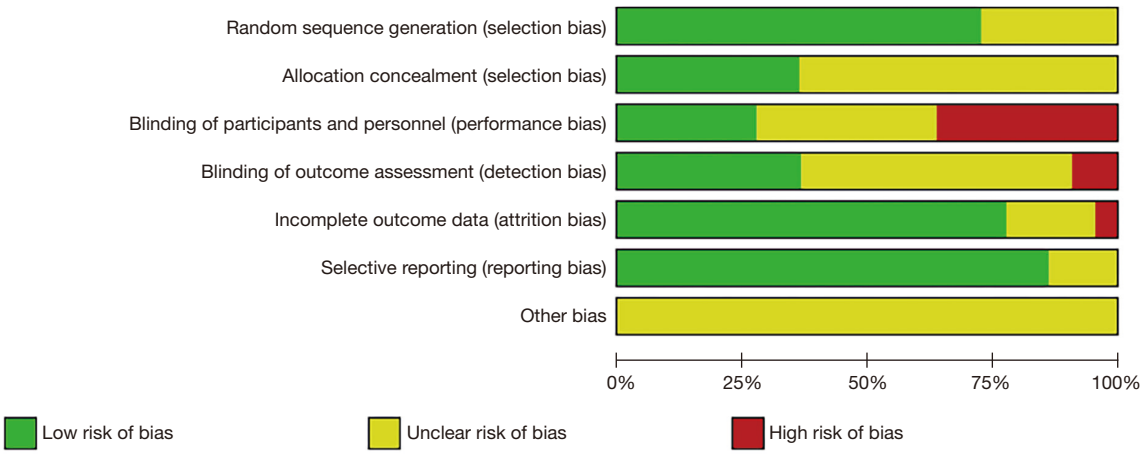

Figure 9 Risk of bias graph.

differential incremental QALYs (0.026 QALYs) yielded an ICER of €–21,707/QALY. The number of days lost due to cardiovascular rehospitalizations in the intervention group (0.33±0.15) was significantly lower than in the control group (0.79±0.20) (P=0.037). These results indicated that telemedicine was significantly more cost-effective than usual care.

However, Henderson *et al.* (20). obtained opposite results on a similar trial. They reported that total health and social care costs (including direct costs of the intervention) for the three months preceding the 12-month interview were £1,390 (€1,610, $2,150) and £1,596 for the usual care and telehealth groups, respectively. The QALY gain by patients using telehealth in addition to usual care was similar to that of patients receiving usual care only, and total costs associated with the telehealth intervention were higher. Therefore, the authors concluded that telehealth did not seem to be a cost-effective addition to standard support and treatment.

It is not possible to make a definitive conclusion on cost-effectiveness due to the differences in study designs and definitions of what constitutes telemedicine. For instance, there is a significant cost difference between a simple SMS message service and a specifically designed vital sign monitoring device. Although it remains unclear whether telemedicine can reduce medical costs, there is undoubtedly a continuing and ongoing role for telemedicine in health care.

Quality (risk-of-bias) assessment

Among the included studies, 71% demonstrated an adequate random sequence generation (15/21), 38% reported allocation concealment (8/21), 29% had no risk-of-bias concerning the blinding between participants and personnel (6/21), 76% had an adequate explanation and follow-up report of missing data, and 86% had no risk of reporting bias (18/21) (*Figures 9,10*).

Given the nature of telemedicine, it is hard—or even impossible—to blind the participants as most of the selected studies were single-blinded or open trials. Additionally, some of the outcomes concerning QoL or mental health assessment were self-reported, which may also explain the heterogeneity among included studies.

Assessment of reporting biases

We used the analysis for systolic blood pressure for the assessment of reporting bias since it included the most of the studies. We had a heterogenesis of I^2=90%. An assessment of heterogeneity is considered an essential part of meta-analysis. As shown in the funnel plot of the effect measures and standard errors constructed by RevMan software (*Figure 11*), half of the studies fell outside the pseudo 95% confidence interval. By visual confirmation, the scattering pattern did not reflect a symmetrical inverted triangle, indicating that the included studies had significant heterogeneity. To confirm this observation, we conducted Begg and Egger tests using Stata software, the results of which are shown in *Tables 3,4*.

These two tests resulted in different heterogeneity assessments. The Begg test indicated no heterogeneity P>0.05), but the Egger test revealed the presence of

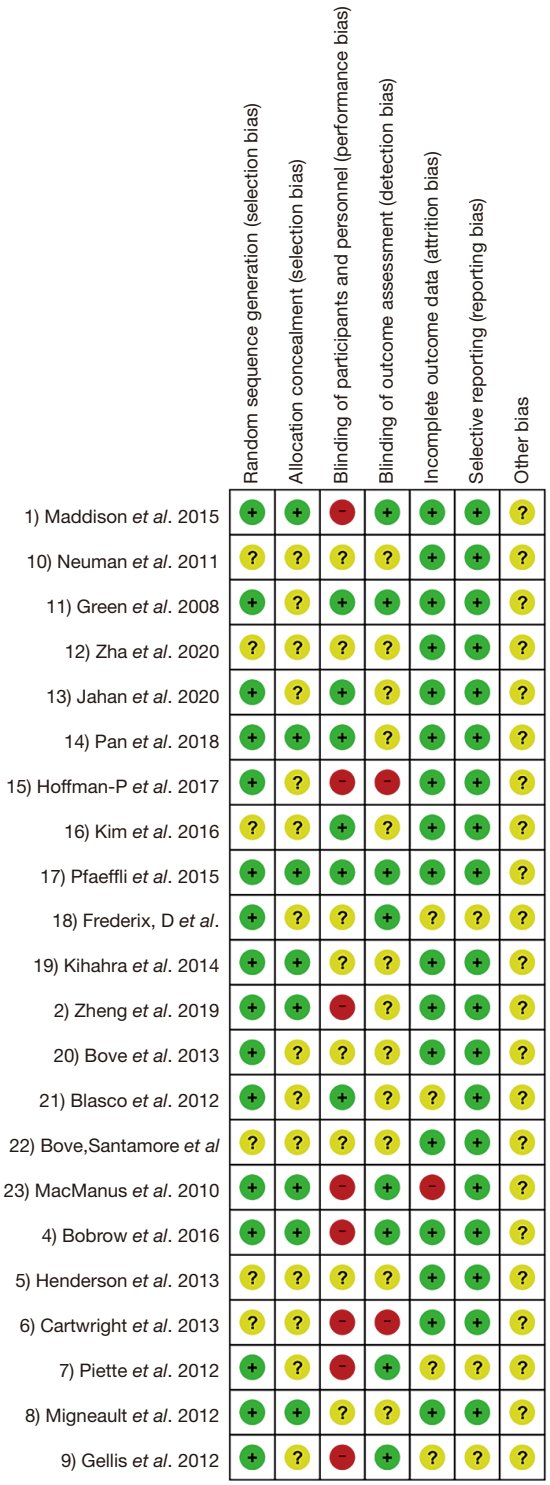

Figure 10 Risk of bias summary.

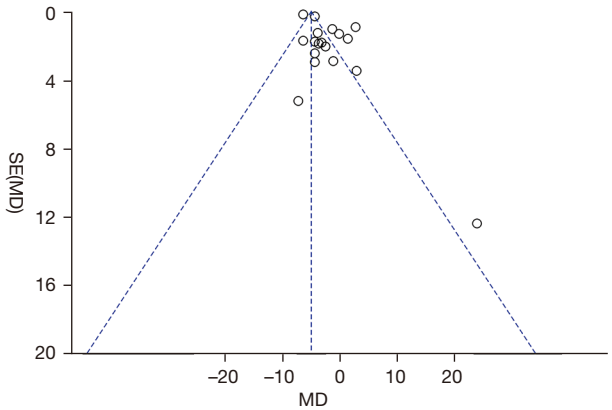

Figure 11 Funnel plot of included studies.

Table 3 Begg's test

Begg's test	Values
adj. Kendall's Score (P-Q)	−15
Std. Dev. of Score	26.40
Number of Studies	18
z	−0.57
Pr > |z|	0.570
z (continuity corrected)	0.53
Pr > |z| (continuity corrected)	0.596

Std.Dev, standard deviation.

heterogeneity (P<0.05). Considering the funnel plot, we chose the Egger test results that indicated heterogeneity between the selected studies.

To determine the origin of the reporting biases, we conducted a meta-regression and a sub-group analysis.

Meta-regression of SBP outcome

We set three covariates for the meta-regression: var2 = year of publication, var10 = duration of the intervention, and var12 = country, with the results shown in *Tables 5,6*.

None of the three covariates were identified as the origin of the bias (P>0.05). This result is acceptable because more than three covariates co-exist in reality. For example, although the intervention method of each study can generally be categorized as telemedicine health care, the

Table 4 Egger's test

Std_Eff	Coef.	Std. Err.	*t*	P>|t|	95% Conf. Interval
slope	−6.000996	0.5599288	−10.72	0.000	−7.187992, −4.814
bias	2.384452	0.802385	2.97	0.009	0.6834721, 4.085433

Std. Err, standard error; Conf. Interval, confidence interval.

Table 5 Parameters of meta-regression

Meta-regression	Number of obs =17
REML estimate of between-study variance	tau2 =8.595
% Residual variation due to heterogeneity	I-squared_res =88.29%
Proportion of between-study variance explained	Adj R-squared =−20.45%
Joint test for all covariates	Model F [3,13] =0.23
With Knapp-Hartung modification	Prob > F =0.8715

REML, restricted maximum likelihood.

Table 6 Results of meta-regression

_ES	Coef.	Std. Err.	*t*	P>|t|	95% Conf. Interval
var2	0.021289	0.3255384	0.07	0.949	−0.6819939, 0.724572
var10	1.247593	1.656411	0.75	0.465	−2.330866, 4.826052
var12	−0.0830117	1.238399	−0.07	0.948	−2.758409, 2.592386
_cons	−47.53386	656.0467	−0.07	0.943	−1,464.837, 1,369.769

var2, year of publication; var10, duration of the intervention; var12, country; Std. Err, standard error; Conf. Interval, confidence interval.

details differ as each study has its own design and definition of "telemedicine". Strictly speaking, each intervention is different, so it is not possible to conduct a sub-group analysis on intervention types. Apart from the intervention design, the patients' demographic details, duration of trials, and timing of blood pressure measurements (whether in the morning or evening) all differed considerably across studies. In conclusion, the large number of covariates contained in the studies made it difficult to determine the origin of heterogeneity.

Discussion

As the focus of modern medical treatment is gradually shifting from treatment to prevention and recovery, remote monitoring and telemedicine will be the field of great concern for scientific research institutions and manufacturers in the future. Wireless, network and humanization are the development trend of remote monitoring system in the future. Portable, modular, easy to operate and inexpensive multi-parameter monitoring products will become the mainstream of the market. The development of 4G technology of mobile communication can greatly increase system capacity, improve communication quality and data transmission speed, while seamless roaming technology between different networks can better connect wireless communication system and Internet, thus providing a more stable and stronger technical foundation for remote multi-parameter monitoring system. According to relevant literature reports, experts in related fields in the United States have realized the application of microwave video to a clinic in an airport and the general hospital in another area through remote connection, carrying out remote medical diagnosis and treatment activities, which is the earliest clinical application of remote technology a brand new attempt. The rapid

development of robotics has played an important role in tele-surgery, a process in which a doctor can operate a robot remotely via an Internet connection so that he or she can perform a remote operation on a patient in another area. The surgeon obtains real-time images through the remote system, and then performs remote operation through relevant equipment. Every operation can be transmitted to the patient's surgical robot in real time and quickly through the analog-to-digital conversion of the remote system, and the surgical robot is controlled to complete the operation.

We systematically reviewed the literature and compiled the available evidence concerning the clinical and economic role of telemedicine in the treatment of cardiovascular patients.

However, this meta-analysis was limited in its analysis of intervention-associated costs. Only two studies reported on cost-effectiveness, making it impossible to draw a conclusion for this outcome measure. Additionally, this study suffered from significant methodological limitations. A substantial reporting bias was shown in the included studies, caused by the difference in study designs. The appropriateness of the implementation of telemedicine is often poorly informed or uninformed (37). Of course, many other variations existed, such as duration of interventions, demographic features of participants, and outcome measurements.

A total of five outcomes were analyzed in this review. As mentioned, no conclusion can be drawn concerning the cost-effectiveness of telemedicine due to the limited sample size. Of the six selected studies using BMI as an outcome measure, no significant difference was found between telemedicine and usual care, indicating that telemedicine had no beneficial effect on changes in BMI. Five studies assessed QoL, and after withdrawing one study following the sensitivity analysis, results from the remaining four studies indicated that telemedicine had a beneficial impact on the QoL of patients. All three studies that assessed the patients' mental health showed a beneficial effect of telemedicine over usual care.

This review also found that there were two common telemedicine interventions: telephone-based information systems (including SMS messaging) and home-based blood pressure monitoring. This finding is understandable, given that all included patients had CVD. The meta-analysis of SBP outcomes also showed a positive result in favor of telemedicine. Diastolic blood pressure was not included in this review because of the limited number of reporting articles.

The strengths of this review were a clear systematic search, study selection and review protocol, the inclusion of RCTs, and adherence to the PRISMA (5) and Cochrane handbook (38) methodologies and reporting guidelines. There were limitations to this systematic review. Although most of the included studies demonstrated high-quality designs, there was significant heterogeneity between them. We also did not include non-English language articles. The diversity of study objectives, designs, and outcomes made clear comparisons difficult, and the quality of evidence was variable.

Conclusions

Telemedicine is a potential and promising solution for patients in rural areas where medical services are poorly supported (34). However, there is still much room for the further development of telemedicine in health care, and its reliability and feasibility remain to be tested in future studies. Although our meta-analysis did not report adequate homogeneity between the selected studies, there is evidence of some correlation between telemedicine interventions and improvements in SBP, QoL, and mental health.

Future studies should focus on the outcomes that this review could not provide definitive conclusions for, such as BMI, medical costs, and other important outcomes concerning the health care of cardiovascular patients.

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Footnote

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Supplementary

Table S1 Characteristics of included studies

Num_ID	ID	Publication year	Duration	Intervention/control, n	Female%	Mean age (SD), years	Intervention type	Disease mentioned	Study design	Outcome	Methodological quality (Jadad scale)
1	Maddison *et al.*	2015	24 weeks	85/86	19	60.2 (9.2)	Text messaging	Angina, myocardial infarction, revascularization	RCT	EQ-5D: me1=0.06, sd1=0.1, me2=0.03, sd2=0.1	4
2	Zheng *et al.*	2019	6 months	411/411	14.1	56 (9)	Text messaging	Coronary heart disease	RCT	SBP diff within gr 6mo: me1=−3.2 (14.3), me2=−2.0 (15.0). BMI diff within gr 6mo: me1=−0.1, sd1=2.6, me2=−0.09, sd2=1.68; d=0.03. SAQ: me1=1.7, sd1=10.6, me2=0.6, sd2=10.1; d=0.11. EQ-5D: me1=0.01, sd1=0.1, me2=0, sd2=0.13; d=0.09	4
3	Frederix *et al.*	2016	24 weeks	69/70	18	61 (8)	Comprehensive cardiac telerehabilitation	Chronic heart failure	RCT	Control: Cost (€) =2,720.21; Effect (QALYS)=0.36. Intervention: Cost=2,155.81; Effect (QALYS)=0.39; ICER=−21,707	3
4	Bobrow *et al.*	2016	12 months	458/457	28	54 (11)	Interactive SMS texting	Hypertension	RCT	SBP diff within gr 0: me1=135.1 (16.9), me2=135.4 (17.6); 6mo: me1=130.1 (16.6), me2=128.9 (17.1); N1=245, N2= 213; diff1=−5 (16.75), diff2=−6.5 (17.35)	5
5	Henderson *et al.*	2013	12 months	534/431	39.79	70.045 (11.14)	Telehealth equipment and monitoring services	Heart failure,	RCT	Control: Cost (£)=5,555 (4,748 to 6,362) (95% CI); Effect (QALYS)=0.549 (0.52 to 0.577). Intervention: Cost=6,193 (5,491 to 6,895); Effect (QALYS)=0.564 (0.535 to 0.585); ICER=79,000	2
6	Cartwright *et al.*	2013	12 months	431/328	40.9	70.24 (11.61)	Telecare & telehealth	Heart failure	RCT	EQ-5D (95CI; sd) 0: me1=me2=0.576 (0.547 to 0.609; 0.33, 0.29); 4mo: me1=0.676 (0.552 to 0.62; 0.36), me2=0.565 (0.529 to 0.604; 0.35); 12mo: me1=0.576 (0.547 to 0.609), me2=0.552 (0.524 to 0.594). brief-STAI 0: me1=9.565 (9.039 to 10.149), me2=9.916 (9.215 to 10.558); 4mo: me1=10.968 (10.384 to 11.728), me2=11.495 (10.792 to 12.254); 12mo: me1=10.734 (10.149 to 11.377), me2=11.552 (10.851 to 12.312). CESD-10 0: me1=9.091 (8.572 to 9.676; 4.13), me2=8.961 (8.313 to 9.610; 4.24); 4mo: me1=9.545 (8.896 to 10.195), me2=10.325 (9.742 to 11.170); 12mo: me1=9.545 (8.896 to 10.195; 4.86); me2=10.390 (9.675 to 11.039; 4.46); 12mo diff1=0.454 (4.5), diff2=1.429 (4.35)	4
7	Piette *et al.*	2012	6 weeks	89/92	67.4	57.6 (0.8)	Automated telephone monitoring and behavior-change calls plus home BP monitoring	Hypertension	RCT	SBP (mm Hg) mean (SE) 0: me1=153.2 (2.1), me2=150.0 (2.1); 6w: me1=142.5 (2.3), me2=143.6 (2.4); diff1=−10.7 (2.2), diff2=−6.4 (2.26). CESD-10 mean (SE) 0: me1=11.1 (0.7), me2=10.7 (0.7); 6w: me1=8.3 (0.65), me2=10.6 (0.62); diff1=−2.8 (0.68), diff2=−0.1 (0.66)	5
8	Migneault *et al.*	2012	1 year	169/168	70.34	56.55 (11)	A novel automated telephone counseling system	Hypertension	RCT	SBP (mmHg) within group diff (SD) 8mo: me1=−2.06 (19.8), me2=0.25 (18.6)	3
9	Gellis *et al.*	2012	12 months	57/58	65.68	79.19 (7.38)	A multidimensional telehealth treatment model	Heart failure	RCT	CES-D 0: me1=19.9 (5.1), me2=20.5 (8.8); 12mo: me1=10.4 (5.8); me2=18.7 (9.4); diff1=−9.5 (5.46), diff2=−1.8 (9.1)	5
10	Neuman *et al.*	2011	3 months	28/29	52.63	56.05 (16.39)	Telemetric BP monitoring	Arterial hypertension	RCT	SBP (mmHg) within group diff (P) 3mo: me1=−17.055 (19.8), me2=−9,863 (19.8)	2
11	Green *et al.*	2008	12 months	258/259	52.2	59.1 (8.5)	Home blood pressure monitoring and web communication	Hypertension	RCT	SBP (mmHg) within group diff (95%CI) 12mo: me1=−5.3 (−7.1 to −3.5), me2=−8.2 (−10.0 to −6.4); diff1=−5.3 (10.43), diff2=−8.2 (10.45)	5
12	Zha *et al.*	2020	6 months	12/13	88	none	Wrist-cuff BP monitor with an ihealth myvitals mobile app	Hypertension	RCT	SBP (mmHg) (SD) 0: me1=145.77 (5.10), me2=145.67 (3.68); 3mo: me1=140.55 (5.46), me2=142.62 (5.69); 6mo: me1=137.38 (4.86), me2=140.88 (5.01); 6mo diff1=−8.39 (4.98), diff2=−4.79 (4.4)	1
13	Jahan *et al.*	2020	5 months	209/211	85.95	47.1 (8.47)	SMS text messaging and health education	Hypertension	RCT	SBP (mmHg) 0: me1=136.9 (19.2), me2=136.9 (19.3); 3mo: me1=127.9 (17.5), me2=132.1 (17.2); diff1=−9 (18.37), diff2=−4.8 (18.28). EQ-5D 0: me1=0.70 (0.10), me2=0.71 (0.10); 2mo: me1=0.76 (0.11), me2=0.76 (0.11); 5mo: me1=0.75 (0.09), me2=0.75 (0.09)	3
14	Pan *et al.*	2018	3 months	52/55	53.27	57.55 (10.66)	A connected automated sphygmomanometer	Hypertension	RCT	SBP (mmHg) diff within group 6mo: me1=−16.4 (12.3–18.3; 7.8), me2=−9.8 (6.2–13.5; 9.77)	4
15	Hoffmann-Peterson *et al.*	2017	3 months	175/181	45.5	60.45 (2.75)	Telemedical home blood pressure measurements	Hypertension	RCT	SBP (mmHg) diff within group 3mo: me1=−8 (12), me2=−8 (13)	3
16	Kim *et al.*	2016	6 months	52/43	68	57.6 (8.6)	Wireless bp self-monitoring program	Hypertension	RCT	SBP (mmHg) 0: me1=136.1 (15.2), me2=145.9 (19.5); 6mo: me1=133.4 (12.9), me2=140.2 (18.4); diff1=−2.7 (14.1), diff2=−5.7 (18.96)	3
17	Pfaeffli Dale *et al.*	2015	6 months	61/62	18.7	59.45 (11.14)	Text messaging and internet support	Coronary heart disease	RCT	SBP (mmHg) 0: me1=131 (17), me2=129 (26); 6mo: me1=136 (20), me2=135 (16), diff1=5 (18.56), diff2=6 (13.6). BMI 0: me1=31.0 (6.4), me2=28 (4.2); 6mo: me1=30.3 (5.4), me2=28.1 (4.4)	5
18	Frederix, Dominique *et al.*	2015	24 weeks	69/70	17.99	61 (8.48)	Internet-based and patient-specific telerehabilitation program with text messaging support	Cardiac patients	RCT	SBP (mmHg) 0: me1=126 (21), me2=129 (25); 24w: me1=150 (140), me2=129 (21); diff1=24 (100.1), diff2=0 (23.09). BMI 0: me1=28 (5), me2=28 (4); 6mo: me1=28 (5), me2=27 (5); diff1=0 (5), diff2=−1 (4.53)	5
19	Kihahra *et al.*	2014	6 months	30/27	64.91	64.41 (7.12)	Home blood pressure (HBP) monitoring	Hypertension	RCT	SBP (mmHg) within group diff (SD) 6mo: me1=−5.5 (0.9), me2=0.7 (0.7)	3
20	Bove *et al.*	2013	6 months	120/121	65.15	59.59 (13.59)	Self-monitoring of BP and an Internet- and telephone-based communication system	Hyperlipidemia	RCT	SBP (mmHg) within group diff (SD) 6mo: me1=−18.2 (20.3), me2=−13.9 (18.2). BMI (kg/m^2) 6mo: me1=−0.2 (2.8), me2=0.5 (4.5)	3
21	Blasco *et al.*	2012	12 months	102/101	19.7	60.8 (11.77)	An automatic sphygmomanometer, a glucose and lipid meter with a cellular phone and a web app	Coronary heart disease	RCT	SBP (mmHg) within group diff (95CI) 12mo: me1=−5.1 (−12.09 to −0.10; 21.84), me2=−0.81 (−6.5 to 4.9; 20.67). BMI (kg/m^2) 12mo: me1=−0.37 (−0.8 to 0.04; 1.53), me2=0.38 (−0.11 to 0.85; 1.74)	4
22	Bove, Santamore *et al.*	2011	12 months	193/195	45.88	61.35 (10.06)	Disease-management interactive health surveillance system composed of a secure internet server and a database	Hyperlipidemia, hypertension	RCT	SBP (mmHg) 0: me1=146.4 (18.0), me2=145.6 (18.7); 12mo: me1=134.3 (17.9), me2=136.5 ± 18.6; diff1=−12.1 (17.95), diff2=−9.1 (18.65). BMI 0: me1= 31.8 (6.5), me2=31.9 (6.3); 12mo: me1=31.6 (6.9), me2=31.7 (6.5); diff1=−0.2 (6.7), diff2=−0.2 (6.4)	2
23	MacManus *et al.*	2010	12 months	234/236	54.26	66.6 (8.8)	Self-monitoring of blood pressure and self-titration of antihypertensive drugs, combined with telemonitoring of home blood pressure measurements	Coronary heart disease	RCT	SBP (mmHg) 0: me1=151.9 (150.8 to 153.1; 8.93), me2=152.0 (150.9 to 153.2; 8.97); 6mo: me1=138.8 (136.6 to 141.0; 17.08), me2= 142.6 (140.5 to 144.8; 16.77); 12mo: me1=134.7 (132.3 to 137.0), me2=140.3 (138.0 to 142.6); 6mo diff1=−13.1 (13.63), diff2=−9.4 (13.45). EQ-5D diff 6mo: me1=0.011 (−0.013 to 0.034), me2=0.000 (−0.023 to 0.023); 12mo: me1=0.024 (−0.001 to 0.049), me2=−0.003 (−0.027 to 0.021)	3

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