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Research Article

The Effectiveness of Telemedicine in Improving Patient Adherence to Anti-hypertensive Medications: A Meta-analysis

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Abstract

Hypertension is one of the most common chronic diseases worldwide. Prompt management reduces severity and morbidity. Telemedicine has the potential to do such. This study compares the effectiveness of telemedicine with standard of care, and standard of care alone in improving adherence to anti-hypertensive medications and lowering blood pressure. A meta-analysis was conducted. PRISMA diagram was utilized. Search of studies was done using PubMed, Cochrane, and Google Scholar. Search terms were telemedicine, hypertension, adherence, and randomized. Data were analyzed using RevMan, generating Forest plots for mean differences and odds ratios in medication adherence, blood pressure changes, and blood pressure control/ improvement across all included studies. Twenty studies were included. Patients in the telemedicine group demonstrated significantly higher medicine adherence scores compared to those given usual care (Std. Mean Difference 1.36, 95% CI: 0.23 to 2.49, p=0.02). There was a significant difference in the proportion and considerable heterogeneity with those monitored with telemedicine having controlled blood pressure post -trial, than those treated with usual care (OR 2.75, 95% CI: 1.64 to 4.61, p<0.01). The average SBP change under the telemedicine group was significantly lower by 6.80 mmHg compared to those enrolled under standard of care alone (95% confidence interval: -9.64 to -3.96, p<0.01). The average DBP change under the telemedicine group was significantly lower by 3.02 mmHg (95% confidence interval: -4.97 to -1.07, p<0.01). The results have led to a conclusion of effectiveness of telemedicine among hypertensive patients. A deep evaluation of its applicability to managing other diseases is worth considering.

Keywords: Telemedicine, Hypertension, Adherence, Meta-analysis, blood pressure

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Introduction

Hypertension is a critical health problem, as it deals with extensive and unpredictable outcomes. As of March 2025, more than 1.3 billion adults all over the world are hypertensive. There is about 28 % of the population in South Asia and 40 % in Africa having blood pressure elevation. Five million cardiovascular-related deaths are mainly attributed to hypertension (Mishra et al., 2025). There are various clinical trials that have been used to identify effective preventions and treatments for hypertension. In a study, "the combination of education, counseling and management strategies" are the most beneficial in reducing blood pressure (Xia et al., 2022).

The rapid growth of technological advancements led to innovations in the medical community, expecting to reap high quality of care and treatment for patients. Technology is continuously developed to level up patient education, counseling, and management. As most of the hospital facilities, medical equipment, and machineries are technologically elevated, the

interaction between health professionals and patients are also considered to adapt smart advancements. Medical industry has established the use of telemedicine to communicate with patients. Telemedicine offers convenience to patients who prefer to seek medical advice remotely, or from the comforts of their homes or workplaces. Eventually, telemedicine is aligned in e-health coverage that utilizes different media networks to discuss particular health issues. Telemedicine is legitimately approved for use in medical industry because of its high potential to deliver healthcare services to people. It allows patients to expand their medical accessibility online by learning more information about the particular disease and to strengthen their knowledge on self-management (Zhang et al., 2022).

Health professionals developed their willingness to provide healthcare services at any given situation. To put it in place, they have expanded their ideas and access to reach numerous patients around the globe. Telemedicine was used as a method to deliver effective medical care to people who seek health guidance even from a distance. This can be performed in any form such as short messaging service (SMS), software application, website, and others. Health professionals can setup a schedule between them and their patients to talk about situations, concerns, and treatment procedures. A certain review shows that telemedicine can be "equivalent" or even more clinically effective in many clinical scenario (Snoswell et al., 2023).

With the increasing number of hypertensive patients, and accelerated mortality rate, health professionals should also explore the use of telemedicine to improve the situation, in terms of medication adherence and favorable outcomes.

Objectives of the Study

The general objective of this study is to compare the effectiveness of telemedicine with the standard of care and standard of care alone in improving the adherence to anti-hypertensive medications. It also aims to determine the effects of telemedicine with standard of care in systolic and diastolic blood pressure (SBP and DBP). Furthermore, the study is to evaluate the effectiveness of telemedicine according to the type of technology used: web-based, application-based, and short message service (SMS).

Methodology

Study Design

This study is a meta-analysis which compared the effectiveness of telemedicine with standard of care and standard of care alone in improving patient adherence to anti-hypertensive medications, by reviewing and analyzing relevant results of available literatures. The review was limited to peer-reviewed journals in any language. Study design included was limited to trials only for the past 10 years. Specifically, this included the following studies:

(1) Randomized clinical trials published for the past 10 years
(2) Conducted among subjects at least 18 years of age and above, who are clinically diagnosed with hypertension, with or without other comorbidities
(3) Intervention should be telemedicine strategies as defined in this study, with standard of care
(4) Control should be the standard of care
(5) Outcome should be improved adherence to anti-hypertensive medications and reduction in systolic and diastolic blood pressure from baseline.

Exclusion criteria were as follow:

(1) Non-comparative clinical trials, animal experiments, and reviews
(2) Duplicate studies or those that were republished
(3) Cross-sectional studies, case series, cohorts, case reports and other gray literature (exclusion of these is to assure uniformity in research design, intention, and outcome measures across all included studies)
(4) Studies where the number of hypertensive adults were inconclusive

Intervention and Outcome

Intervention in the included studies involved telemedicine defined by common elements such as information or telecommunication technologies like SMS, software applications, websites, and others. The control was the current standard of care which includes pharmacologic (e.g., anti-hypertensive medications), non-pharmacologic (e.g., lifestyle modification, patient education), or alternative and complementary interventions. Both groups within a study received the same standard of care and did not receive other interventions that may interfere with the outcome of the study. The primary outcome of this study was the medication adherence among participants receiving the intervention or the standard of care alone. Secondary outcome measure was the changes in systolic and diastolic blood pressure from the baseline.

Search Strategy

Literature search from PubMed/MEDLINE, Cochrane Central Register of Controlled Trials

(CENTRAL) in The Cochrane Library, and Google Scholar was done. Search terms used included: telemedicine AND hypertension AND adherence AND randomized. Included studies were searched for related citations. The investigators independently carried out study selection, review, risk of bias assessment, data extraction, and analysis. The Preferred Reporting Items for Systemic Reviews and Meta-analyses (PRISMA) was also utilized.

Risk of Bias Assessment

The risk of bias was assessed for each study and included in the final analysis, following the modified revised Cochrane risk-of-bias tool for randomized trials (RoB 2) tool. Domains reviewed were randomization process, deviations from intended interventions, missing outcome data, measurement of the outcome, and selection of the reported result. Each domain was classified as low risk, with some concerns, or high risk.

Data Collection and Analysis

The investigators used a standard form to independently extract study characteristics and outcome data from the studies. The following information were collected: study design, patient characteristics such as age, type of telemedicine, and outcomes such as medication adherence, blood pressure control, and reduction of SBP and DBP. Review Manager (RevMan) 5.4 software was used in the analysis of data. Use of RevMan in the field of health is widely accepted due to its comprehensive analysis of odds ratios, mean differences, and risks of bias. Its standardized reporting generates Forest plot, and most importantly conforms with PRISMA. Odds ratio and mean difference or standardized mean difference, together with the 95% associated confidence interval for dichotomous and continuous data were determined. Heterogeneity was assessed by using Chi-square test and I2 test.

RESULTS

Descriptive Statistics

The search of Pubmed/MEDLINE, Google Scholar, and Cochrane provided a total of 660 citations. After adjusting for duplicates and reviews, 419 remained. Of these, 289 studies were discarded. After reviewing the titles and abstracts, it appeared that these papers clearly did not meet the criteria. The full text of the remaining 130 citations were examined in more details. It appeared that 110 studies did not meet the inclusion criteria as described. Twenty studies met the criteria and were included in the meta-analysis (Figure 1).

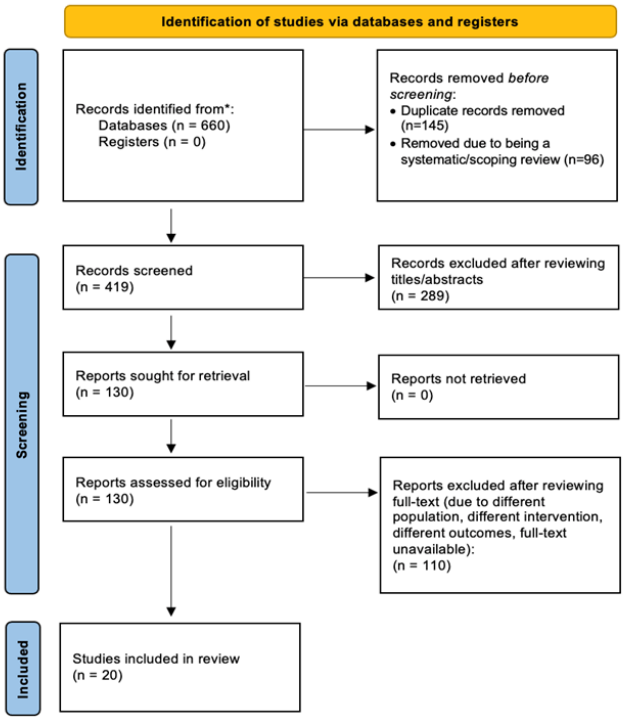


Figure 1

PRISMA 2020 Flowchart

Table 1 summarizes the individual characteristics of the studies included.

Table 1. Characteristics of included studies

	Country	Blinding	Inclusion criteria	Exclusion criteria	N	Age in years	Outcome measures assessed	Key results
Bobrow 2016	South Africa	Single - Interventionists	- 21+ y/o - prescribed anti-HTN meds	-requiring specialist care for their hypertension at a hospital - women who reported being pregnant or within three months post-partum - with very high blood pressures (systolic BP >220 mm Hg or diastolic BP >120 mm Hg) who had symptoms suggestive of a hypertensive emergency or were otherwise acutely unwell	915 (T:458; C:457) Males: 253 (T: 127; C: 126)	T: 53.9 ±11.2 C: 54.7 ±11.6	→ SBP change → adherence (PDC>=80%) → hospital admissions	Telemedicine outcomes are better.
Buis 2017	USA	None	- 18+ y/o - with uncontrolled HTN (based on ICD-9) - taking at least 1 anti-HTN medication	- strict adherence to antihypertensive medication regimens - undergoing hemodialysis - plans to move more than 50 miles away from the recruitment site or to terminate cell phone contract within the next three months - compliance risk as identified by a score ≥2 on the CAGE Questionnaire Adapted to Include Drugs (CAGE-AID) for substance/alcohol abuse - any other major health problem that would make follow-up difficult	123 (T:60; C:63) Males: 54	49 ±8.3	→ Adherence to medication based on MMAS, MASES → SBP, DBP change → Patient satisfaction	No statistical association found.
Chandler 2019	USA	None	-21-65 y/o - Hispanic/ Latino - uncontrolled HTN - prescribed medication for hypertention	- inability to use a smartphone, a Bluetooth BP device, and electronic medication tray - untreated psychiatric illness, alcoholism or substance abuse, medical diagnoses besides type 2 diabetes mellitus (e.g., cancer treatment within past two years, stroke, myocardial infarction) pregnancy, lactation or intention to become pregnant during the trial - participation in another clinical trial - inability to speak, hear, or understand English or Spanish	54 (T:26; C:28) Males: 19 (T:8; C:11)	T: 44.4 ± 7.2 C: 46.8 ± 8.1	→ SBP, DBP change → controlled SBP (SBP <140mmHg) → controlled DBP (SBP <90mmHg) → medication adherence	Telemedicine outcomes are better.
Frias 2017	USA	None	- uncontrolled HTN & T2DM - failed treatment with >=2 anti-HTN meds	- BMI >=40kg/m2 - skin sensitivity to adhesive medical tape or metals - active or chronic dermatitis secondary causes for uncontrolled HTN or T2DM - evidence of hypertensive emergency	109 (T:80; C:29) Males: 54 (T:35; C:19)	T: 57.8 ± 1.1 C: 61.6 ± 1.7	→ SBP, DBP change	Telemedicine outcomes are better (improved DBP).

Table 1. Characteristics of included studies

	Country	Blinding	Inclusion criteria	Exclusion criteria	N	Age in years	Outcome measures assessed	Key results
Karami 2023	Iran	None	- 30+ y/o - uncontrolled HTN - prescribed anti-HTN meds	- underlying chronic diseases, including cardiovascular disease, diabetes, and cancer - pregnant women	118 (T:59; C:59) Males: 59 (T:31; C:28)	52.2 ± 15.55	→ SBP, DBP change	No statistical association found.
Kim 2016	South Korea	None	- 18+ y/o - taking at least 1 anti-HTN medication - completed 6 -month follow-up visit		95 (T:52; C:43) Males: 30 (T:14; C:16)	57.6 ±8.7 T: 57.5 ±8.6 C: 57.7 ±8.7	→ SBP, DBP change → achieved blood pressure control	No statistical association found.
Liu 2023	China	Single - Data collectors	- 18-80 y/o - taking at least 1 anti-HTN medication for at-least 1 month	- secondary HTN - mental disability or inability to speak - not having a sphygmomanometer at home	297 (T:148; C:149) Males: 148 (T:78; C:70)	T: 48.58 ± 9.54 C: 50.64 ± 8.72	→ SBP, DBP change → achieved blood pressure control	Telemedicine outcomes are better.
Margolis 2015	USA	None	- uncontrolled HTN	- Stage 4 or 5 kidney disease - Albumin-to-Creatinine ratio >700mg/g - acute coronary syndrome, coronary revascularization, or stroke within the past 3 months; - known secondary causes of hypertension - pregnancy - NYHA class III/ IVheart failure or known LVEF <30 %.	403 (T:206; C:197) Males: 229 (T:118; C:111)	T: 62.3 ±11.4 C: 60.2 ±12.1	→ SBP change	Telemedicine outcomes are better.
McGilicuddy 2015	USA	Single - Data collectors	- KT patients 3 months prior - taking at least 3 medications for immunosuppresion and hypertension	- inability to self-administer medications, measure own blood pressure, use mobile phone - history of psychiatric illness or substance abuse - pregnant, lactating, or intending to become pregnant during the trial	18 (T:9; C:9) Males: 10 (T:4; C:6)	T: 42.44 ± 12.04 C: 57.89 ± 8.72	→ SBP change → achieved blood pressure control	No statistical association found.
Mehta 2024	USA	Single - Investigators, Analysts	-18-75 yo - diagnosed with HTN with at least 2 hospital visits in the past 2 years	- metastatic cancer, end-stage kidney disease, congestive heart failure, dementia, or a BMI≥50	149 (T:100; C:49) Males: 39 (T:26; C:13)	T: 50.7 ± 10.1 C: 49.1 ± 11.5	→ SBP change → achieved blood pressure control	No statistical association found.
Meng 2023	China	None	- 18+ yo - uncontrolled BP	- secondary HTN - CKD, CLD, MI, stroke, CHF - dementia severely impaired hearing or speech - malignant tumors	172 (T:84; C:88) Males: 101 (T:50; C:51)	T: 50.96 ± 10.5 C: 51.45 ± 12.22	→ SBP, DBP change → achieved blood pressure control → medication adherence	Telemedicine outcomes are better

Table 1. Characteristics of included studies

	Country	Blinding	Inclusion criteria	Exclusion criteria	N	Age in years	Outcome measures assessed	Key results
Naqvi 2022	USA	Single - Outcome assessors	- acute ischemic or hemorrhagic stroke discharged home after hospitalization with a diagnosis of hypertension	- disability, pregnancy, severe psychiatric illness, dialysis, or long-term BP goal ≥140/90	50 (T:25; C:25) Males: 32 (T:16; C:16)	64.3 ± 14.0 T: 65.9 ± 15.6 C: 62..6 ± 12.4	→ SBP change → achieved SBP control	Telemedicine outcomes are better
Nolan 2018	Canada	Single - Outcome assessors, Analysts	- 35-74 yo - stage 1-2 HTN	- clinically significant sleep apnea, kidney disease, psychiatric illness, including depression, alcohol or drug dependence	264 (T:133; C:131) Males: 110 (T:59; C:51)	T: 58 ± 11.77 C: 57.2 ± 8.76	→ SBP, DBP change	Telemedicine outcomes are better
Nurakysh 2022	Kazakhstan	None	- 18-75 yo - with arterial HTN - at least 1 anti-HTN medication	- pregnant women - disability due to mental or cognitive impairments - technical difficulties	425 (T:224; C:201) Males: 234 (T:157; C:77)	T: 63.9 ± 2.9 C: 62.8 ± 4.1	→ medication adherence	Telemedicine outcomes are better
Ralston 2014	USA	Single - Outcome assessors	- 25-75 yo - taking anti-HTN medications - no diabetes, cardiovascular, renal disease, or other serious conditions		383 (T:186; C:197) Males: 192 (T:104; C:88)	T: 59.8 ± 8.6 C: 59.8 ± 8.3	→ achieved blood pressure control	Telemedicine outcomes are better
Schoenthaler 2020	USA	Single - Interventionists	- 18+ y/o - with uncontrolled HTN - taking at least 1 anti-HTN medication		42 (T:21; C:21) Males: 23 (T:11; C:12)	57.6 ± 11.1 T: 59.7 ± 10.7 C: 54.5 ± 11.3	→ SBP, DBP change → medication adherence	No statistical association found.
Treskes 2020	Netherlands	Single - Outcome assessor	- MI patients		200 (T:100; C:100) Males: 156 (T:81; C:75)	T: 60.1 ± 34.69 C: 59.1 ± 30.36	→ achieved blood pressure control	No statistical association found.
Yatabe 2021	Japan	None	- 20+ yo	- pregnancy - presence of major cardiovascular events and diabetes mellitus, - an estimated glomerular filtration rate <30mL/min/1.73 m2 determined using the modified Modification of Diet in Renal Disease formula for Japanese patients	97 (T:49; C:48) Males: 39 (T:21; C:18)	T: 53 ± 9 C: 53 ± 9	→ SBP, DBP change → achieved SBP control	No statistical association found.
Zha 2019	USA	None	- 18-64 - uncontrolled HTN - taking anti-HTN meds	- pregnant women - patients with a serious arrhythmia or preeclampsia	25 (T:12; C:13) Males: 3 (T:2; C:1)	T: 53 ± 9 C: 53 ± 9	→ SBP, DBP change → medication adherence	No statistical association found.

Table 1. Characteristics of included studies

	Country	Blinding	Inclusion criteria	Exclusion criteria	N	Age in years	Outcome measures assessed	Key results
Zhu 2021	China	None	- 35+ yo - with high BP	-cerebral hemorrhage, - unstable angina, - malignant hypertension, -pregnant	350 (T:175; C:175) Males: 178 (T:88; C:90)	T: 48.9 ± 8 C: 55.5 ± 5.2	→ SBP, DBP change → medication adherence	Telemedicine outcomes are better

BP, Blood pressure; C, Control; DBP, Diastolic blood pressure, HTN, Hypertension; MMAS, Morisky Medication Adherence Scale;NR, Not reported; NYHA, New York Heart Association; SBP, systolic blood pressure; T, Telemedicine

Risk of Bias Assessment of Individual Studies

Eight of the 20 reviewed articles exhibited a high risk of bias, primarily due to biased outcome measurement (Figure 2). For seven of these studies [Chandler (2019), Kim (2016), Liu (2023), Meng (2023), Nurakysh (2022), Ralston (2014), and Treskes (2020)], the patients from the telemedicine group self-managed their blood pressure outcomes compared to the control group's reliance on a specialist for recording outcomes. Frias's (2017) and Nurakysh's (2022) studies both raised concerns about the randomization process. Frias' study presented imbalanced sample sizes and statistically significant differences in baseline systolic blood pressure, while Nurakysh's study displayed patients in the intervention group having a longer history of arterial hypertension. Both studies also had high risk of bias over selection of the reported results. Margolis (2015) presented some concerns on the deviations from the intended interventions due to lack of information on non-adherence to telemedicine. On the study of Chandler (2019), two subjects were subsequently dropped due to unidentified exclusion criteria (alcoholism and congestive heart failure) while on the study of Frias (2017), five participants in one usual care site was not included in the final analysis due to violation of the cluster randomization.

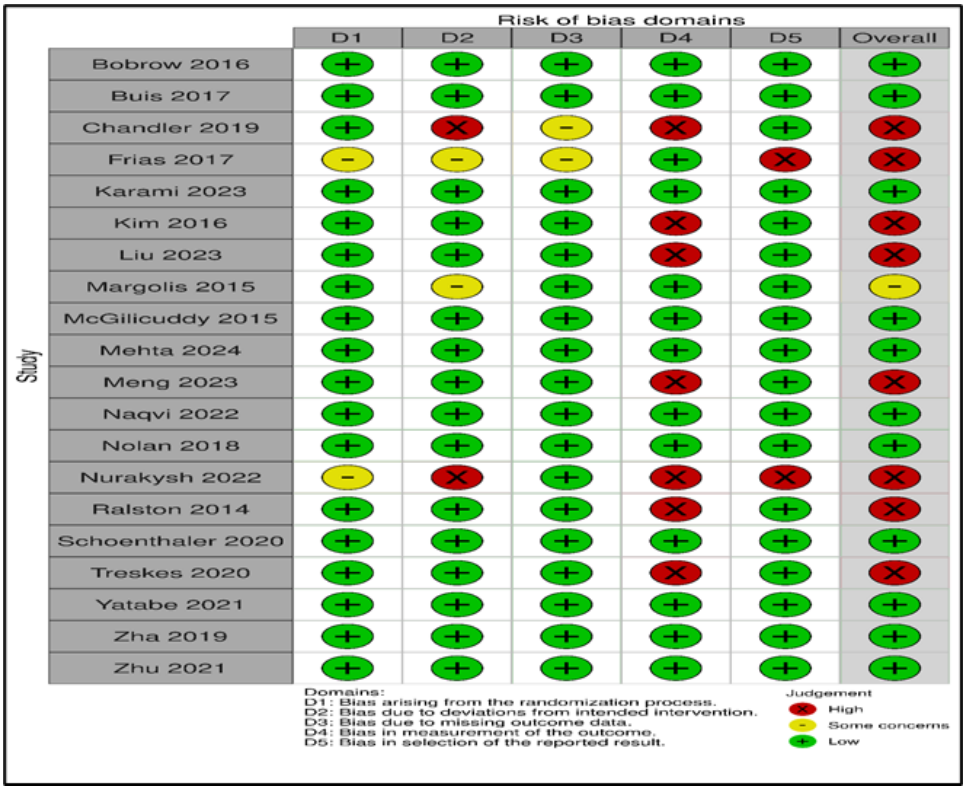


Figure 2

The Review Framework Followed in this Study.

Results of Syntheses

Adherence to anti-hypertensive medications

Seven studies reported medication adherence scores (Figure 3). Buis (2017), Chandler (2019), and Zhu (2021) used the Morisky Medication Adherence Scale (MMAS) as basis in generating adherence scores. Schoenthaler (2020) utilized an Electronic Medical Device (EMD) and MMAS for adherence scoring. Zha (2019) used the Medication Adherence Self-efficacy Scale (MASES). Nurakysh (2022) featured the Lebanese Medication Adherence Scale (LMAS). Meng (2023) used this formula: (number of days taking the medication as required / total days required to take the medication) × 100%.

Patients in the telemedicine group demonstrated significantly higher adherence rates compared to those given usual care (Std. Mean Difference 1.36, 95% CI: 0.23 to 2.49, p=0.02, I^2=98%).

Improved or controlled blood pressure

A total of 2,325 patients from 11 studies had results on improved or controlled blood pressure (Figure 4). There was a significant difference in the proportion and considerable heterogeneity with those monitored with telemedicine having controlled blood pressure post-trial, than those treated with usual care (OR 2.75, 95% CI: 1.64 to 4.61, p<0.01, I^2=80%). Further analysis revealed that application-based and web-based telemedicine approaches were associated with higher blood pressure control rates than usual care. In contrast, those given SMS reminders did not significantly improve blood pressure control compared to standard of care (OR 1.02, 95% CI: 0.73 to 1.44, p=0.90, I^2=0%).

Change in SBP and DBP

Patients under telemedicine experienced significant reductions in both SBP and DBP following the intervention. The average SBP change under the telemedicine group was significantly lower by 6.80 mmHg compared to those enrolled under standard of care alone (95% confidence interval: -9.64 to -3.96, p<0.01). SBP reduction was consistently lower across the different telemedicine types (App, SMS, Web). Meanwhile, the average DBP change under the telemedicine group was significantly lower by 3.02 mmHg (95% confidence interval: -4.97 to -1.07, p<0.01). However, there were no notable differences in the DBP reduction when analyzed across the different telemedicine interventions. These results were based on data from 3,227 patients for SBP and 1,841 patients for DBP (Figures 5 and 6).

On High Heterogeneity

The noticeable high heterogeneity on almost all outcomes measured can be attributed to the diversity of the location from where the studies were conducted, types of comorbidities the included population of each of the study had (e.g. kidney transplantation, type 2 diabetes mellitus, stroke, and others), and the types of telemedicine technology employed (Table 1). The different methods in computing medication adherence scores also contributed to increased heterogeneity.

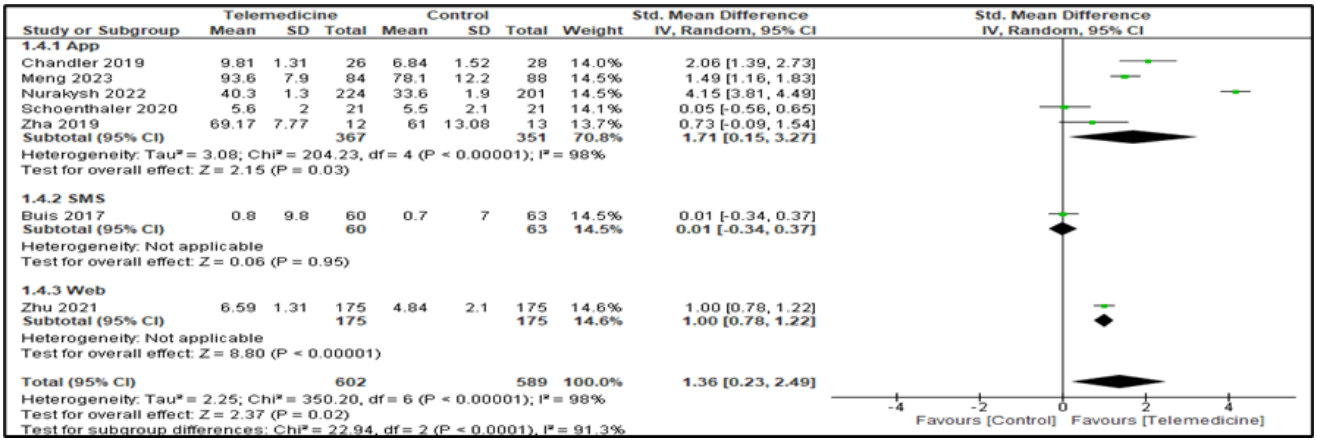


Figure 3

Medication adherence, subgrouped by telemedicine

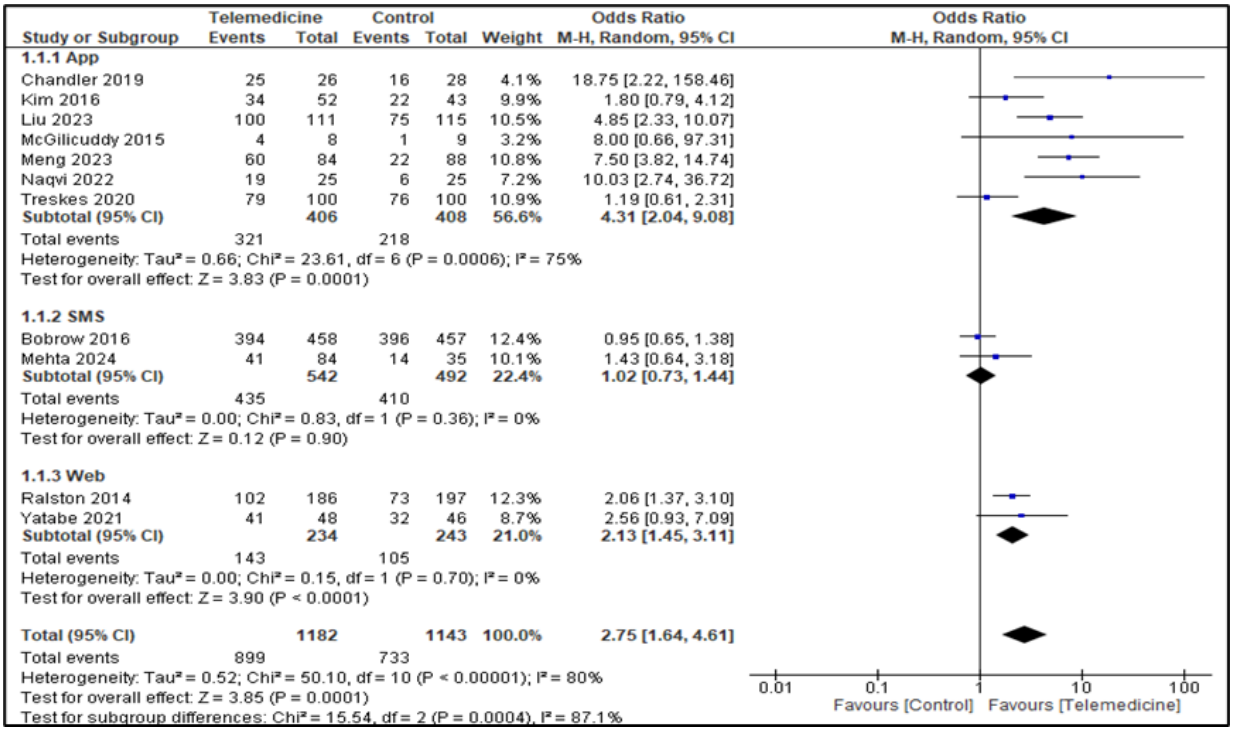


Figure 4

Improved or controlled blood pressure, subgrouped by telemedicine type

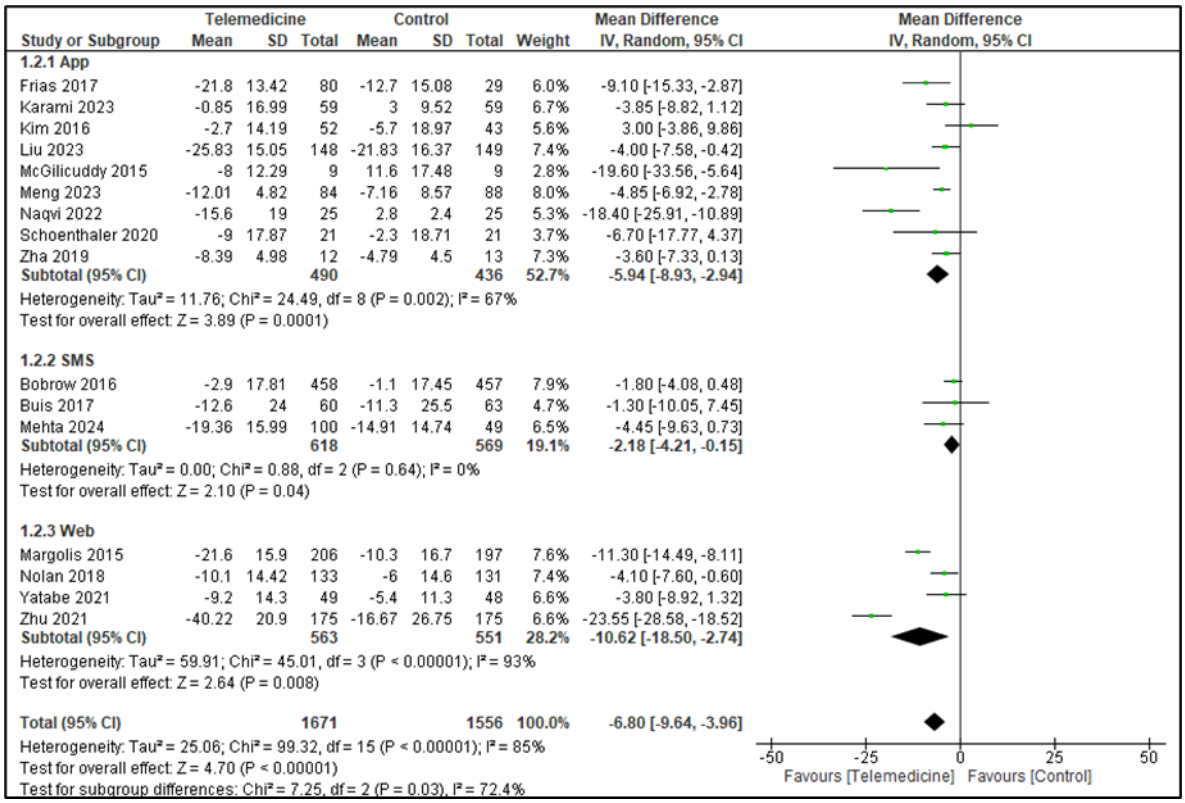


Figure 5

SBP change, subgrouped by telemedicine type

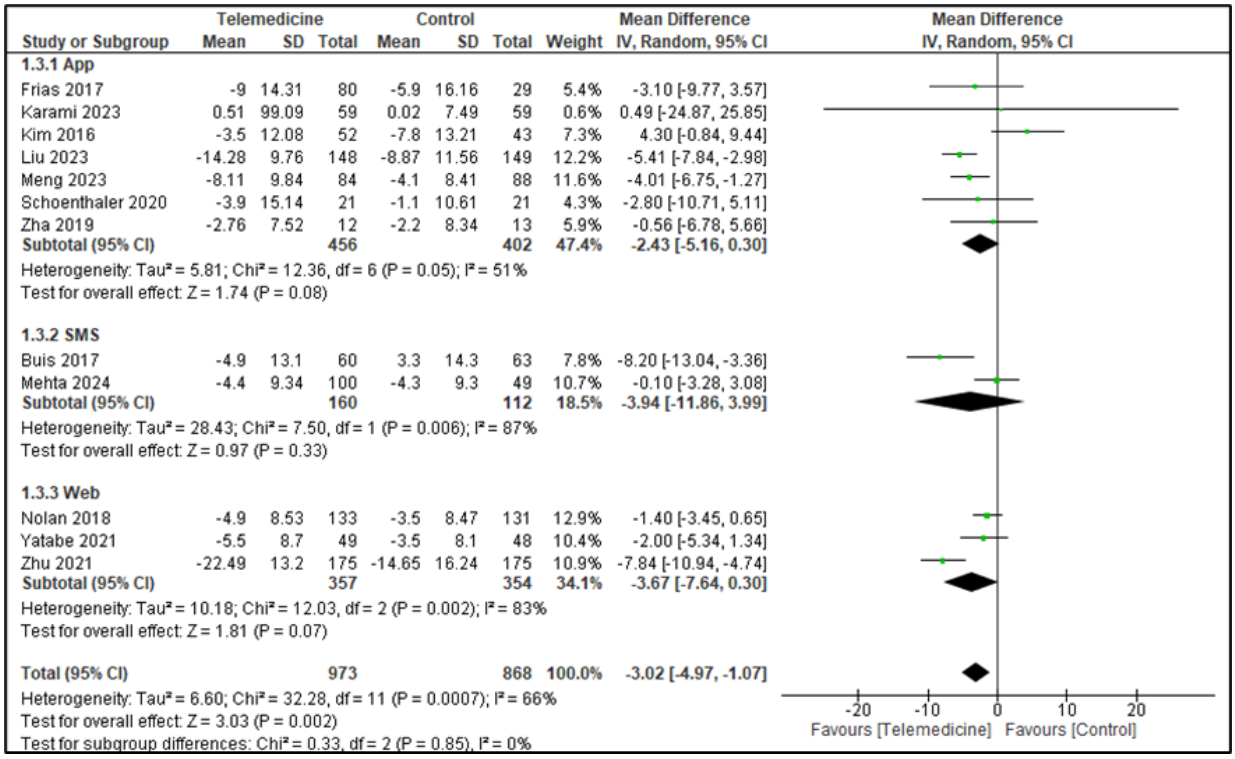


Figure 6

DBP change, subgrouped by telemedicine type

DISCUSSION

This meta-analysis was done to compare the effectiveness of telemedicine with standard of care and standard of care alone. A total of 20 randomized controlled trials were included in this study after thorough identification, screening, and assessment using PRISMA 2020. Primary outcome of medication adherence among patients and secondary outcomes of changes in systolic and diastolic blood pressure from baseline were extracted from the studies and were subjected to appropriate data analysis. Data analysis was done and showed that telemedicine (such as software applications or websites) with standard of care has significantly improved or controlled blood pressure of hypertensive patients as compared to the standard of care alone. It may imply that follow-up with patients through telemedicine, in monitoring their medication intake has a factor in maintaining their maintenance medication adherence. The improvement on blood pressure also reflects on the reductions on SBP and DBP of the telemedicine patients which were significantly lower by 6.80 mmHg and 3.02 mmHg, respectively, as compared with the usual care. These findings prove to be clinically useful. For every 5 mmHg reduction particularly in SBP, the risk of developing cardiovascular events fall by 10 % (Canoy et al., 2022).

CONCLUSION

Nowadays, as technology continues to develop, utilizing telemedicine as part of the healthcare system would bring forth several clinical possibilities. According to Heinzelmann et al. (2005), telemedicine may play a big role in the improvement of healthcare system as it may be considered as a compelling alternative in providing conventional management in different clinical settings thus, improving many clinical outcomes. As such, telemedicine will significantly contribute to the current healthcare sector in addressing health issues including hypertension, diabetes, and other comorbidities.

The effectiveness of telemedicine for medical care of COVID-19 patients during the pandemic was undeniable. As people avoided onsite/ in-person health services due to fear of contracting the disease, telemedicine became a potent instrument to continuously provide medical attention to homes and remote places (Valencia-Arias et al., 2024). The adoption and exploration of telemedicine continue to grow even after the

pandemic. It will not cease today, nor in the future. In fact, telemedicine expansion, to accommodate conditions beyond COVID-19 resonates globally. This meta-analysis for example, has led to a conclusion of its effectiveness among hypertensive patients.

Telemedicine for hypertension serves as augmentation to an already tried and tested standards of care and in-person consultation. This scenario can be exemplified as when a patient receives technology-initiated reminders on medication intake schedule, diet, or lifestyle changes, or when a wearable device that measures blood pressure automatically prompts an alarm to patient, relative, and healthcare provider if it is at a dangerous level. Counseling to modify behaviors and lifestyles, is readily rendered through telemedicine. And soon, artificial intelligence (AI) powered telemedicine platform could be possibly developed to virtually assist or guide a patient on home remedies or automatically contact emergency services during unfavorable circumstances.

This meta-analysis provides a reflection on how telemedicine can possibly address the management of other diseases. A deep evaluation of its applicability to non-urgent management and rehabilitation of patients with diabetes mellitus, stroke, wound care issues, and others is a matter worth considering.

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