SPECIAL THEME

Effectiveness of Telemedicine Programs in Achieving Blood Pressure Control Among Adult Hypertensive Patients: A Meta-Analysis

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Background: The healthcare system began transitioning from a traditional clinic-based consult to telemedicine due to the COVID-19 pandemic. This change makes telemedicine a promising tool for managing diseases from the comfort of one's home.
Objective: This study aimed to determine the effectiveness of telemedicine in blood pressure (BP) control and the most effective mode of telemedicine in BP control among hypertensive patients.
Methods: This meta-analysis was developed following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Search for articles was done using electronic databases (PubMed, MESH, and Clinical key). Identified articles were reviewed independently by two researchers and were statistically analyzed.
Results: Eight studies were included in the final analysis. A statistically significant difference between intervention and control groups was observed for both SBP and DBP (estimated SMD of SBP at 0.19 mmHg (p-value 0.003, chi^2 =30.52, df =11, CI = -0.31 to -0.06) with substantial heterogeneity at 71%; DBP at −0.15 mm Hg (p<.004; x^2=14.19, df =9 95% CI −0.25 to − 0.02) with low heterogeneity at 37%).
Conclusion: Telemedicine is an effective means of reducing blood pressure among adult hypertensives. It enables access to individualized continuing care in hard-to-reach areas where patients with comorbidities are the high-risk groups. Future research can be done using the same output measurement and statistical analysis to determine the most effective mode of telemedicine in controlling blood pressure.

Key words: telemedicine, hypertension, blood pressure

Introduction

Hypertension is the leading cause of cardiovascular disease and premature death worldwide. According to the World Health Organization (WHO), an estimated 1.13 billion people worldwide have hypertension, and the number will increase to 1.5 billion in 2025.[1] Traditional hospital-centered and treatment-based health care systems have been implemented to decrease the prevalence of hypertension. However, despite all the efforts to prevent, timely diagnose, and effectively manage hypertension, its incidence is increasing, and blood pressure control in affected individuals is still unsatisfactory.[2]

In addition to the traditional hospital-centered approach, telemedicine has been widely used in this population during the past decade to provide individualized and continuous support for patients with chronic conditions.[3] The use of telemedicine intensified when the coronavirus disease 2019 (COVID-19) outbreak became a pandemic on March 11, 2020. Video consultation, a form of telemedicine, is promoted to deliver care at a distance and to reduce the risk of transmission in the Philippines and worldwide. It has been endorsed to improve access, efficiency, and quality of life by bridging the gap between professional health care and patient self-management.[4]

Several studies regarding the effectiveness of Telemedicine programs in BP control among adult hypertensive patients gave a weak overall picture leading to the research question: "Are telemedicine programs effective in achieving blood pressure control among hypertensive adults?" This meta-analysis aimed to summarize the telemedicine programs for adult hypertensive patients, identify their effectiveness in controlling blood pressure (BP) and determine the most effective mode of telemedicine in BP control. Findings from this meta-analysis may contribute to more effective management of hypertension and thereby facilitate the improvement of patient-centered health care systems. This paper will also provide important information to healthcare providers, policymakers, and health commissioners about its applicability in the healthcare setting of the country.

Methods

Protocol and Registration

The protocol was registered under the Research Committee of the Philippine Academy of Family Physicians (PAFP) and submitted to the Institutional Ethics Review Board (IERB) of the East Avenue Medical Center with Protocol Number EAMC IERB 2021-33 for approval prior to the conduct of the study. Prior to data extraction, it was registered to the International Prospective Register of Systematic Reviews (PROSPERO) to avoid duplication and reduce opportunities for reporting bias. This meta-analysis was developed following the PRISMA guidelines.

Search Strategy

Researchers combed through electronic databases (PubMed, MESH, and Clinical key) to find relevant studies for articles written in English. A technique combining different MESH or free text phrases was used to search databases. The reference lists of previous systematic reviews and meta-analyses found during the search were examined for further inclusion. Two reviewers independently reviewed the lists of abstracts that resulted from the search. The relevant papers were chosen based on the information collected from the abstracts, which indicated that the qualifying requirements would be met. After excluding papers that were not relevant, original manuscripts of possible eligible publications were retrieved and thoroughly analyzed to determine eligibility.

Data Selection and Extraction

Studies that investigated the effect of telemedicine on the control of blood pressure were included if the following criteria were met: 1) journals published 2010-2020, 2) English-only articles, study population should include patients diagnosed with hypertension regardless of duration, 3) study should include at least two groups, one group being managed via telemedicine and other the face-to-face consult, 4) study should include blood pressure control evaluation, and 5) randomized control trial studies (RCTs). The following study parameters were considered: study design, sample size, study duration, age and gender, type of control used, and the mode of telemedicine. Independent of the overall number of patients included in each trial, outcome measurements such as diastolic and/or systolic blood pressure had to be available. Data were extracted from selected papers by the two reviewers independently and entered into an electronic spreadsheet. In the event of disagreements over study selection or inclusion and data interpretation, a third reviewer was sought to settle the disagreement.

Apart from following the inclusion and exclusion criteria, no specific study quality analysis was performed; nevertheless, statistical approaches such as sensitivity analyses were employed to analyze the influence of excluding or including certain studies on the effect size, as per the PRISMA guidelines (when applicable).

After contacting the respective author, attempts were made to retrieve missing data from the original publications. Aside from that, no statistical approaches were used to replace missing data. When a study included more than one-time points for an outcome, the data for the most prolonged follow-up period was extracted.

Statistical Analysis and Synthesis

Review Manager (RevMan) 5.3 was utilized for data analysis and synthesis. A random effect model was used to conduct the meta-analysis. After the study, standardized weighted mean differences between the intervention and control groups and their 95% confidence intervals were determined for systolic and diastolic blood pressure. The baseline-to-end-of-study difference in blood pressure and the accompanying standard deviation were lacking in specific trials.

The difference was calculated by subtracting the average value after the follow-up period from the baseline value. When the standard deviation of the difference was not known, the standard deviation of the difference was calculated using the elementary theory of differences in correlated variables. When all three standard deviations were reported in studies, the correlation between baseline and the final value was determined and then utilized in conjunction with the later two standard deviations to estimate the standard deviation of change when none were available. Heterogeneity was assessed using I^2.[5,6]

Results

Study Selection and Study Characteristics

A total of 2294 articles were initially identified from the three databases (PubMed, MESH, and Clinical key); 305 were removed because of duplication. The remaining 1989 studies were then screened. We excluded 1342 articles because of the low relevance of the title and abstract to this review. Furthermore, 342 articles were rejected because they were not RCTs, and 62 more were excluded because the mode was not telemedicine. After reviewing the full text of the remaining 243 articles, 235 studies were eliminated upon application of the inclusion and exclusion criteria. All eight studies were included in the meta-analysis. The search and screening strategy is shown in Figure 1.

The characteristics of the trials are summarized in Table 1. The eight articles were published from 2010-2020, where a 12-month duration of intervention was seen in 3 articles. One study done in 2010 and 2018 had a 6-month and 12-month duration. Three other studies used the intervention for two months, six months, and four years. Two studies were evaluated using telephone call interventions; 2 used SMS text messaging, 2 used both SMS and telephone call, 1 used a mobile application, and 1 used a secure website as an intervention. Six of the eight articles used SBP and DBP reductions as the outcome. Two measured the SBP reduction only. Aside from the BP reduction, two studies used other outcomes, such as medication adherence and antihypertensive medications prescribed.

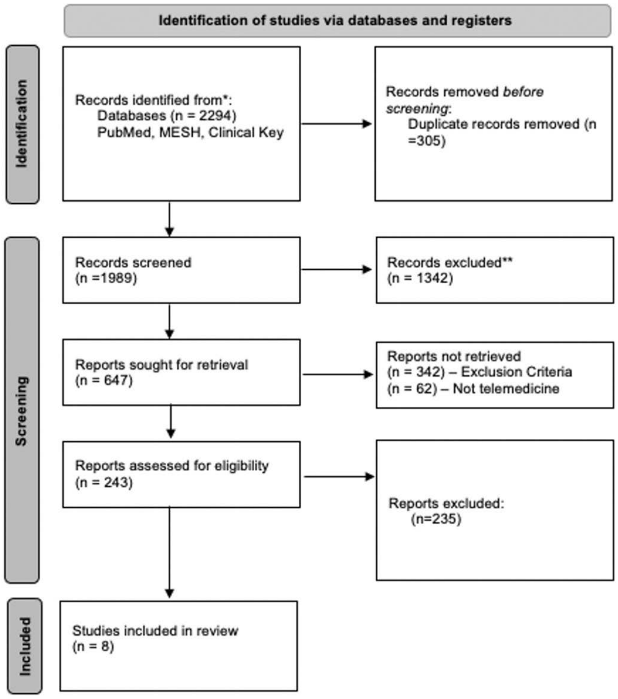

Figure 1. PRISMA flow diagram

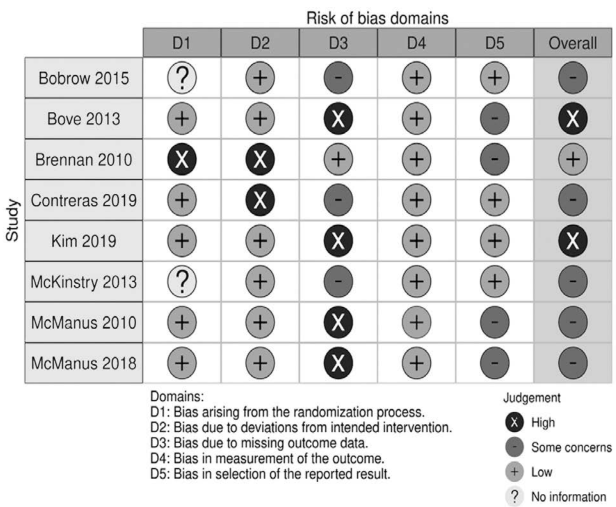

Figure 2A. Risk of bias graph.

Risk of Bias

Since no study was utterly devoid of bias, the total risk was relatively high. A total of eight articles were found to have a low probability of selection bias as shown in Figures 2A and 2B. Others were deemed ambiguous because the sequence generating technique was not classified. Overall, eight studies were included in the analysis. The studies by Bobrow et al. (2016) and McKinstry, et al. (2013) were found to have a risk of bias, while that of Brennan, et al. (2010) was found to have a high risk of bias for the randomization process.[7,10,11] The studies by Brennan, et al. (2010) and Contreras, et al. (2019) reported a high risk of bias due to unclear reporting on intervention deviations.[7,13]

The funnel plot was used to assess the risk for publication bias. The systolic and diastolic BP funnel plots showed symmetry and no evidence of publication bias for the included studies as shown in Figures 3A and 3B, respectively.

Control of Blood Pressure

A meta-analysis was conducted to determine the effect of telemedicine on blood pressure. In the synthesis, three articles reported more than one intervention group (Bobrow 2016; McMannus 2018, and Kim 2019).[11,12,14] One article (Bobrow 2016) used only SBP as the outcome of interest.[11] As a result, 12 interventions were displayed in the SBP forest plot and ten in the DBP forest plot. As shown in Figure 4A, the estimated Standard Mean Difference (SMD) of SBP between intervention and control groups was significant at -0.19 mmHG (p-value 0.003, chi^2 =30.52, df =11, CI = -0.31 to -0.06) with substantial heterogeneity at 71%. There was a statistically significant difference in DBP as −0.15 mm Hg (P<.004; x^2=14.19, df =9 95% CI −0.25 to −0.02) between intervention and control groups with low heterogeneity at 37%, also shown in Figure 4B.

Intervention

Eight included studies used several modalities as interventions. These were assessed to determine which mode of telemedicine is most effective in controlling blood pressure. Out of the eight studies, two studies were evaluated using telephone call interventions, two used SMS text messaging, 2 used both SMS and telephone call, 1 used a mobile application, and 1 used a secured website as an intervention. The

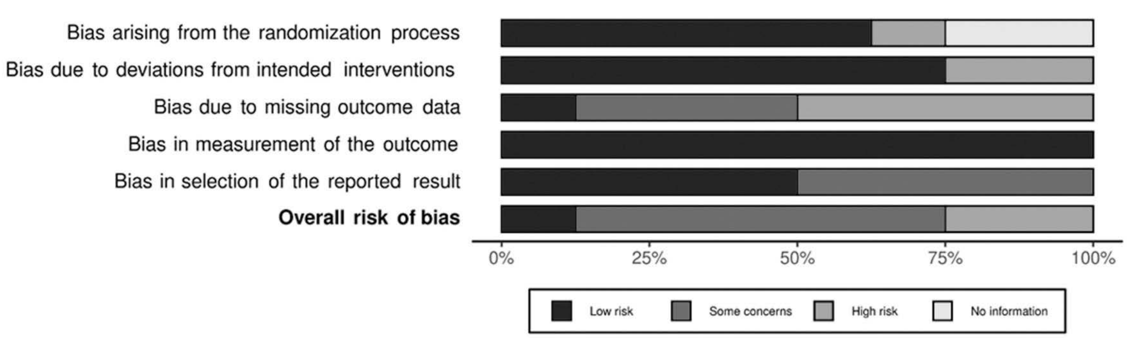

Figure 2B. Results of risk of bias analysis

Table 1. Basic characteristics of studies included.

Author (Year)	Number of subjects	Age	Gender (% of male and female)	Comparison	Intervention (Device used)	Duration of Intervention	Outcome of interest
Brennan 2010[7]	638	Mean age: 55.7	Male: 33% Female: 67%	Usual Care	Self-monitoring of BP evaluated through a telephone call	12 months	SBP and DBP reduction
McManus 2010[8]	480	Mean age: 66.6 (Intervention group); 66.2 (Control group)	Male: 47% (Intervention group); 47% (Control group) Female: 53% (Intervention group); 53% (Control group)	Usual Care	Self-monitoring with or without evaluation through a telephone call and self-titration of antihypertensive drugs	6 months and 12 months	SBP and DBP reduction
Bove 2013[9]	206	Mean age: 59.6	Male: 35% Female: 65%	Usual Care	Telephone-based telemedicine	4 years	SBP and DBP reduction
McKinstry 2013[10]	401	Mean age: 60.5 (Monitored group) Mean age: 60.8 (Usual care group)	Men: 59% (Monitored group); 60% (Usual group) Female: 41% (Monitored group); 40% (Usual group)	Usual Care	Self-measurement and transmission of blood pressure readings to a secure website	6 months	SBP and DBP reduction
Bobrow 2016[11]	1372	Mean Age: 54.4	Male: 28% Female: 72%	Usual Care	Randomized to receive information-only SMS text-messages or interactive SMS text messages	12 months	SBP reduction
McManus 2018[12]	1182	Mean age: 66.8 (Usual care group); 67.0 (Self-monitoring group); 67.0 (Telemonitoring group)	Male: 53% (Usual care group); 54% (Self-monitoring group); 53% (Telemonitoring group) Female: 47% (Usual care group); 46% (Self-monitoring group); 47% (Telemonitoring group)	Usual Care	Self-Monitoring with or without evaluation through SMS text messages	6 months and 12 months	Primary: Change in mean SBP Secondary: Antihypertensive drugs prescribed
Contreras 2019[13]	148	Mean age: 57.5	Male: 48% Female: 52%	Usual Care	Self-monitoring through ALERHTA Application	12 months	Primary: medication adherence Secondary: change of SBP and DBP
Kim 2019[14]	124	Mean age: 77.70 ± 6.92 (Control) Mean age: 77.50 ± 6.38 (Health coaching) Mean age: 77.21 ± 6.69 (Long-message Service) Mean age: 78.25 ± 6.61 (Health coaching with long-message service)	Male: 64.5% (Control); 63.3% (Health coaching); 37.5% (Long-message Service); 54.8% (Health coaching with long-message service) Female: 35.5% (Control); 36.7% (Health coaching); 62.5% (Long-message Service); 45.2% (Health coaching with long-message service)	Usual Care	Intervention 1: Phone-based health coaching Intervention 2: Long-message service Intervention 3: Phone-based health coaching and long-message service	2 months	SBP and DBP reduction

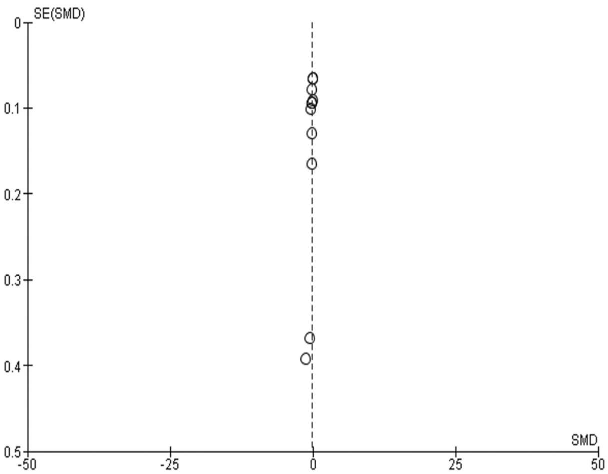

Figure 3A. Funnel plot of systolic blood pressure.

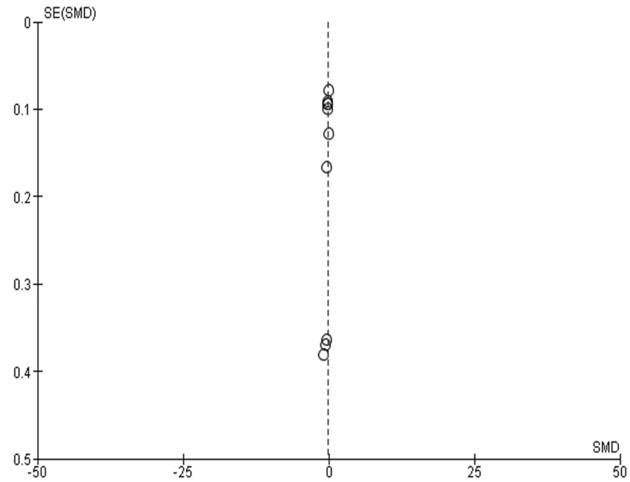

Figure 3B. Funnel plot of diastolic blood pressure.

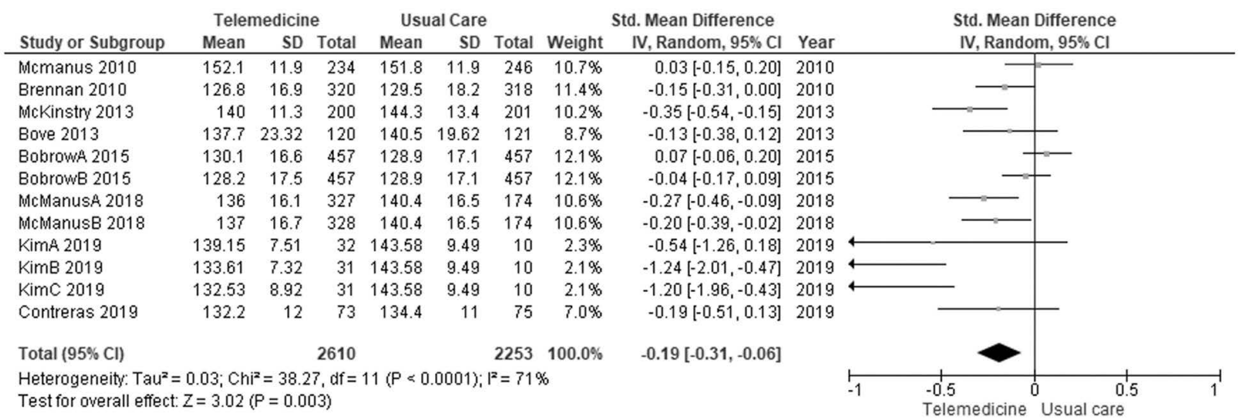

Figure 4a: The effect of telemedicine on the control of systolic blood pressure.

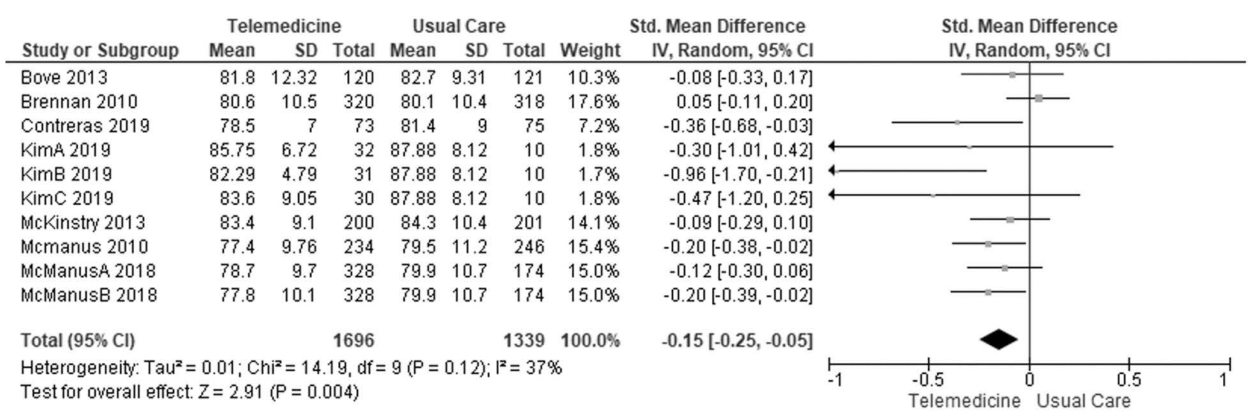

Figure 4b. The effect of telemedicine on the control of diastolic blood pressure.

most effective mode of telemedicine could not be identified because of the different outcomes of measurement used by each study.

Telephone call

Brennan (2010) and Kim A (2019) used mean ± standard deviation as the outcome measurement, observing a reduction in systolic and diastolic blood pressures.[7,14] The study by Brennan (2010) had a reduction of SBP (132.9 ± 20.5 to 126.8 ± 16.9) and DBP (83.6 ± 12.3 to 80.6 ± 10.5) among 638 hypertensive African American patients after 12 months of treatment.[7] Whereas, Kim A (2019) achieved SBP decrease (141.16 ± 18.28 to 132.53 ± 8.92) and DBP decrease (87.10 ± 10.54 to 83.60 ± 9.05) among 124 hypertensive patients after two months of intervention.[14]

McMannus (2010) and Bove (2013) used Mean Difference ± Standard deviation for the outcome measurement, with both studies achieving a reduction of systolic and diastolic blood pressure.[9,12] Bove (2013) achieved a mean difference in SBP of −18.2 ± 20.3 and DBP of −4.9 ± 10.2 among 206 African Americans without overt cardiovascular disease after six months of intervention[9] Whereas McMannus (2010) achieved a reduction of -17.6 mmHg in SBP and -7.5 mmHg in DBP among 480 hypertensive patients after 12 months.[12]

SMS Text Messaging

Bobrow (2016) used SBP mean differences (95% CI) when comparing systolic blood pressure reduction using information-only messages (−2.2 (−4.4 to −0.04)) and interactive SMS text messaging interventions (−1.6 (−3.7 to 0.62)), among 1,372 hypertensive patients who were mostly of black African and mixed ancestry.[11] McMannus (2018) also observed a -4.7 reduction in the mean SBP and a -1.5 reduction in DBP among 1182 hypertensive patients after 12 months of intervention.[12] Kim B (2019) observed a reduction in SBP from 142.90 ± 12.08 to 139.15 ± 7.51 and DBP from 87.25 ± 7.87 to 85.75 ± 6.72 among 124 hypertensive patients after two months of intervention.[14]

Telephone Calls and SMS Text Messaging

Kim C (2019) used both telephone calls and SMS text messaging as interventions and noted a reduction in SBP of 142 ± 13.33 to 133.61 ± 7.32 and DBP from 86.61 ± 5.63 to 82.29 ± 4.79 among 124 hypertensive patients after two months of treatment.[14]

Mobile Application

Contreras (2019) used a mobile application called ALERHTA as an intervention and noted a mean decrease in SBP of 2.5 ± 11 and DBP of 3.14 ± 9 among 148 hypertensive patients after 12 months of intervention.[13]

Secure Website

Lastly, McKinstry (2013) used a secure website and noted the reduction of SBP (146 mmHg to 140 mmHg) and DBP (87.4 mmHg to 83.4 mmHg) after telemonitoring among 1182 hypertensive patients after six months of intervention.[10]

Discussion

Overall, the meta-analysis showed statistically significant differences in SBP (z= 3.02, p-value 0.003) and DBP (z= 2.91, p-value 0.004) between intervention and control groups. The Standard Mean Difference (SMD) of SBP was significant at -0.19 mmHg and DBP at −0.15 mmHg.

Previous meta-analytic studies exist regarding the use of telemedicine in controlling blood pressure among hypertensive patients.[15,16] Tucker, et al. showed that a combination of self-monitoring and tele-counseling had greater SBP and DBP reductions. Furthermore, the study by Han, et al. on the effect of mobile applications on blood pressure control showed additional reductions in BP in the intervention group.[16]

While our study has similar positive results to the meta-analyses above, it differs from others regarding the selected population. Several telemedicine meta-analyses included subjects with comorbidities (e.g., Diabetes mellitus, stroke).[16,17,18] Lv, et al. observed a reduction in SBP by an average of 5.49 mm Hg with telemedicine among stroke survivors.[18] Mao, et al. observed that mobile health intervention had a greater effect on BP reduction in managing patients with hypertension and diabetes.[19] Similarly, the study by Zhang, et al. demonstrated a significant decrease in blood pressure by 10.4/4.8 mmHg with telemedicine among patients with hypertension and DM.[17] The varying degree of BP reduction may be due to the study participants having uncontrolled hypertension worsened by comorbidities. In contrast, this meta-analysis only included studies of adult hypertensives without comorbidities since concurrent diseases may affect the response to telemedicine programs.

This study showed a significant reduction in the baseline blood pressure among adult hypertensives using telemedicine. This effectiveness of telemedicine enables the provision of continuing care to hypertensive patients in rural and hard-to-reach areas, especially in times of pandemic, where patients with comorbidities are the vulnerable and high-risk groups. Telemedicine also allows the implementation of community programs for hypertension in this time of limited resources, time, and patient-physician contact. Filipino families will have more efficient access to medical services and will be given individualized management.

The most effective mode of telemedicine was not determined as there were variable data available and different statistical analyses used in each study. The narrative of the included studies showed that a significant decrease in both the SBP and DBP was observed, whatever the mode of telemedicine used.

Conclusion and Recommendation

A meta-analysis of eight clinical trials showed that the use of telemedicine effectively reduces blood pressure among adult hypertensives

The effectiveness of telemedicine enables access to individualized continuing care for hypertensive patients in hard-to-reach areas, especially in times of pandemic, where patients with comorbidities are the vulnerable and high-risk groups.

The researchers recommend that future research to determine the most effective mode of telemedicine in controlling blood pressure be done using meta-analysis of studies using the same output measurement and statistical analysis.

Telemedicine can be recommended to other health care providers in managing hypertensive patients. Policymakers can include the application of telemedicine into the universal health care program of the country and incorporate it into the community programs for hypertension.

By these, the researchers fulfill the role of a five-star family physician, as a social mobilizer, by emphasizing primary prevention, timely diagnosis, and effective management at a distance.

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