Current Hypertension Reports (2022) 24:247–258
https://doi.org/10.1007/s11906-022-01186-5

TELEMEDICINE AND TECHNOLOGY (HB BOSWORTH, SECTION EDITOR)

A Systematic Review of the Role of Telemedicine in Blood Pressure Control: Focus on Patient Engagement

Ahmad Khanijahani[1] · Nesli Akinci[2] · Eric Quitiquit[1]

Accepted: 9 March 2022 / Published online: 12 April 2022

Abstract

Purpose of Review To systematically review and synthesize the existing evidence on the effects of different telemedicine interventions on improving patient engagement among patients with hypertension. Patient engagement is defined as patients' knowledge, skills, ability, and willingness to manage their healthcare within the context of interventions designed to promote positive patient behaviors.

Recent Findings Telemedicine is a rapidly growing method of healthcare services delivery. Telemedicine interventions are mainly used to facilitate communication between the patient and provider, measure, record, and track blood pressure, and educate and train patients about managing their blood pressure. Findings from several studies indicate the evidence of patient engagement, adherence to the care plan, improvement in knowledge about blood pressure, and patient satisfaction with telemedicine interventions for blood pressure.

Summary Telemedicine interventions need to be customized depending on patient demographics and socioeconomic characteristics such as age and education level to ensure optimal patient engagement.

Keywords Telemedicine · Telehealth · Blood pressure · Hypertension · Patient engagement · Patient adherence

Abbreviations

BP	Blood pressure
HBPM	Home blood pressure monitoring
HBPT	Home blood pressure telemonitoring
HIT	Health information technology
IVR	Interactive voice response
SMS	Short messaging service
AIM	Advice and interactive messaging
DMO	Digital medicine offering

Introduction

Telemedicine is continuously growing as a practical method of healthcare service delivery nationally and globally across various healthcare settings. The advent of the COVID-19 pandemic has brought telemedicine interventions to the forefront of healthcare offerings and highlights more than ever the importance of optimizing telemedicine interventions so they can best serve patients, providers, and healthcare systems [1••, 2••]. Though individual telemedicine offerings vary in their structure and organization, telemedicine is broadly defined as the act of delivering healthcare services over a distance using information and communication technologies to aid in the diagnosis, treatment and prevention, research and evaluation, and the continuing education of healthcare providers [3]. Despite potential challenges in implementing telemedicine interventions, such as protecting the privacy of patient data, technological costs, and the heterogeneity of these interventions, the use of telemedicine has increased substantially over time. In 2010, 35% of hospitals in the USA were fully or partially implementing a computerized telehealth system and, by 2017, this percentage rose to 76% [4]. A 2016 World Health Organization (WHO) survey found that 87% of countries ($n = 109$) reported implementing at least one mobile health (e.g., telemedicine through mobile phones and patient monitoring devices) program and that 57% of the responding countries ($n = 70$) recognized telehealth at a national policy level [5].

This article is part of the Topical Collection on *Telemedicine and Technology*

✉ Ahmad Khanijahani
khanijahania@duq.edu

[1] Department of Health Administration and Public Health, John G. Rangos School of Health Sciences, Duquesne University, 600 Forbes Avenue, Pittsburgh, PA 15282, USA

[2] Dr. Kiran C. Patel College of Osteopathic Medicine, Nova Southeastern University, Davie, FL, USA

Telemedicine is becoming increasingly popular to manage patients with chronic conditions such as diabetes, heart disease, and hypertension. Blood pressure (BP) monitoring and control through telemedicine is particularly of interest as nearly 50% of US adults have hypertension, and only about 24% of them have their hypertension under control [6]. In 2017, over 472,000 individuals' primary or contributing cause of death in the USA was hypertension, and hypertension cost the USA approximately $131 billion each year between 2003 and 2014 [7, 8]. Healthcare systems must develop and implement efficient hypertension management methods to lower the disease burden nationally and globally. Previous studies, including randomized controlled trials, suggest that home blood pressure telemonitoring (HBPT) improves blood pressure control in patients with hypertension. Additional studies have demonstrated a significant reduction in BP through regular HBPT than usual care [9]. Telemedicine, therefore, presents a promising method of facilitating the care and management of patients with hypertension.

Although previous studies demonstrate improvements in BP control and reductions in BP through telemedicine interventions, less is known about the effects of telemedicine on patient engagement among patients with hypertension. In this review, we define patient engagement as patients' knowledge, skills, ability, and willingness to manage their healthcare within interventions designed to promote positive patient behaviors [10]. Increasing and improving patient engagement may be a strategy whereby healthcare systems, providers, and patients observe improved health outcomes, lower costs, and better patient care [10]. Optimizing patient engagement may also contribute to achieving a more patient-centered approach to healthcare, which is increasingly valued in the current healthcare climate [11]. Therefore, assessing the effects of telemedicine on improving patient engagement among patients with hypertension can offer essential insights to enhance the care of hypertensive patients. Insufficient patient adherence to treatment and clinical inertia (the inability of healthcare providers to initiate or intensify therapy appropriately) are the two major causes of inadequate BP control [12]. Telemedicine offers a unique approach to target such concerns and can potentially improve outcomes for patients. To our knowledge, to date, there is no comprehensive review of empirical studies on the effects of telemedicine on improving patient engagement in patients with hypertension. The purpose of this systematic review was to compile and assess the existing relevant literature, fill current knowledge gaps by providing comparative evidence about the impact of telemedicine on improving patient engagement in patients with hypertension, and inform future research and policy development on this topic.

Methods

Databases and Search Strategies

We searched PubMed, Wiley Online Library, Scopus, and Embase for relevant studies until July 2020. After restricting our search terms to include different variations of telemedicine, patient engagement, and hypertension, the initial search yielded 775 results. Table 1 includes the search terms and the general search strategy.

Inclusion and Exclusion Criteria

Only original research articles published in peer-reviewed journals were included in this review. Other formats, such as book chapters, viewpoints, and comments, were excluded. If possible, we restricted the results to journal articles in the search process. Otherwise, we eliminated the other publication formats during the review of the search results. Only articles published in English were included in this review. Table 2 details the study selection and inclusion criteria.

Study Screening and Selection Criteria

The flow diagram in Fig. 1 demonstrates the study selection process for this systematic review based on the preferred reporting items for systematic reviews and meta-analyses (PRISMA) [13]. A total of 775 studies were initially identified through database searching (PubMed, Wiley Online Library, Scopus, and Embase). After removing duplicated

Table 1 Keywords and search strategy

Category 1: telemedicine	Category 2: patient engagement	Category 3: hypertension
"e-Health" OR "eHealth" OR "telemedicine" OR "telehealth" OR "tele-health" OR "telecare" OR "health information technology" OR mhealth OR "mobile health"	"patient involvement" OR "patient empowerment" OR "patient participation" OR "patient activation" OR "patient engagement" OR adherence	"blood pressure" OR hypertension

Search strategy: 1 AND 2 AND 3

Table 2 Study selection and inclusion criteria

1. Intervention: introduction or use of telemedicine or telehealth technology among those with hypertension
2. Outcome: changes in patient participation, engagement, or adherence
3. Language: only published in English
4. Format: only peer-reviewed original research papers. Exclude other publications such as, book chapters, viewpoints, commentaries, and letters to the editor

results, 580 studies remained. Of those studies, 560 studies were deemed irrelevant and excluded from further analysis after reviewing the title of the studies. Twenty studies remained and were assessed for eligibility. Another seven studies were excluded after a complete review of these studies with relevant reasons listed in Fig. 1. Ultimately, thirteen studies were included in this systematic review.

Results

Summary Study Characteristics

Table 3 summarizes the sample sizes, study designs, interventions, and primary findings for the thirteen studies included in this systematic review. The publication dates for the included articles ranged from 2012 to 2019. Seven studies were from North America (six from the USA and one from Canada), one from South America (Bolivia), three from Western Europe (two from Sweden and one from England), one from East Asia (China), and one study location could not be identified.

Types and Purposes of Telemedicine Technologies Used in the Studies

Communication with Patient and Reminders

A variety of telemedicine platforms and technologies were utilized in the reviewed studies. In most studies ($n = 10$), patient communication was predominantly achieved through mobile phones [14–21, 22•, 23]. The communication strategies utilized in these nine studies included a smartphone application [15–19, 23], text messaging [22•], interactive voice response (IVR) calls [21], and a mobile-friendly website [20]. In one study, patients uploaded their BP data to an online portal via a home computer or clinic kiosk [14]. Another study employed an online portal that could be accessed by mobile phone or computer [24]. In two studies, the telemedicine intervention primarily targeted healthcare providers and included a teleconference system [25] and the electronic medical record [26].

Seven studies included a component of the telemedicine intervention that sent reminders to patients. These reminders were sent to remind patients about taking medications [16, 18], recording and submitting BP readings [14, 15, 19], and about their upcoming appointments [17, 24].

Recording, Tracking, and Monitoring Blood Pressure

The studies varied in terms of how BP was measured and recorded. In eight studies [14, 15, 18, 19, 21], BP was self-recorded by patients. In two studies [16, 22•], BP was recorded in a clinical setting. Feedback provided to patients included automated email or text messages to reinforce monitoring in patients who were actively monitoring BP [14], tailored text messages to patients who were not providing enough BP recordings [14], a five-star rating system to rate the patient's adherence to BP monitoring [14], automated responses that described actions patients should take if BP readings were outside of an acceptable range [15], graphs and figures of self-reported data [14, 17, 18], and immediate feedback after each BP recording that included an enthusiastic animation and positive reinforcement language [19]. Patients' BP data were reviewed by a clinician either periodically [14–16, 18, 20] or as seen fit, and patients could be contacted with further information if needed [15, 16, 20]. Clinician notifications could also be prompted when patients were not taking medications or their BP and glucose level values were worrying [21].

Patient Training and Education

Nine studies [14–19, 21, 22•, 23] included a patient education or training component. Patients were educated about the benefits of managing their BP on their overall health and well-being, and clinicians identified target levels for patients' systolic BP (SBP) and diastolic BP (DBP) values [14]. Patients were also sent text messages containing educational information [15, 22•] and received training on measuring their BP [15, 16]. In two studies, the smartphone

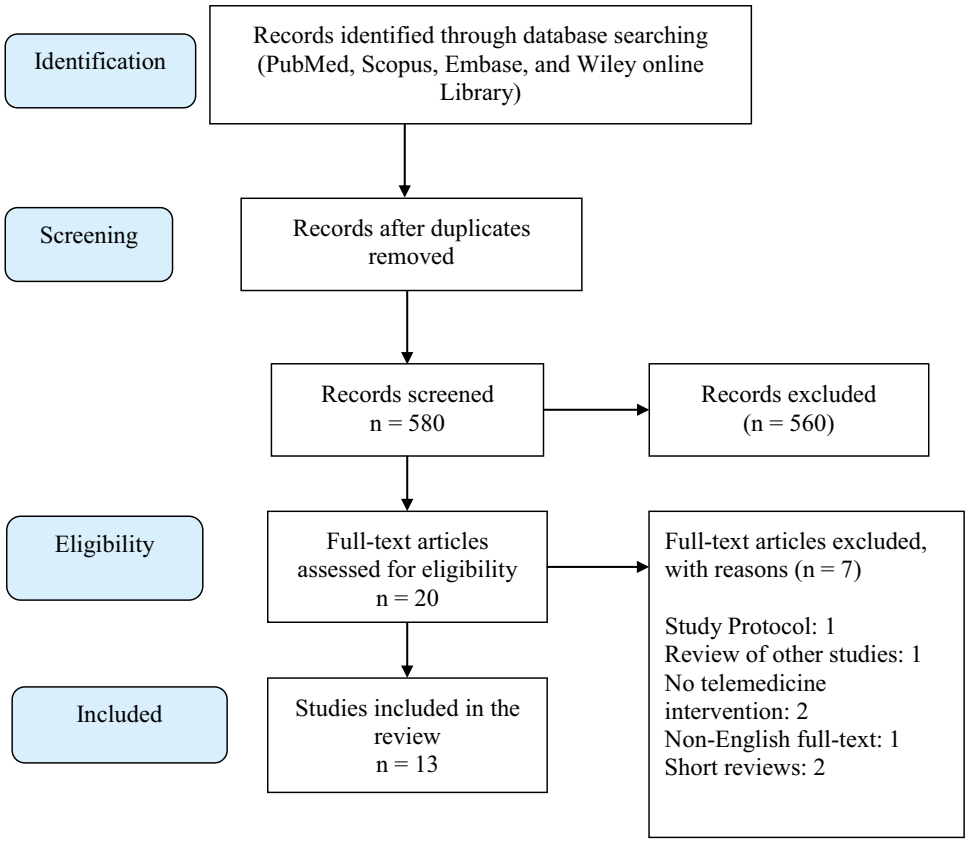

Fig. 1 Flow diagram of article selection based on the preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines

application had an educational component that consisted of modules that informed patients about their condition and how to manage it at home [17, 19]. Patients also received education about disease self-management based on their responses to IVR call questions [21].

Patient Outcomes

Patient Engagement and Adherence

Three studies demonstrated improvements in patient engagement upon implementing a telemedicine intervention [19, 21, 23]. Patients were actively involved in their medical care by self-monitoring their heart rates and blood pressures. They experienced significantly better drug therapy adherence and significantly improved quality of life scores [17]. In addition, through self-monitoring and self-reporting BP and other health data, patients could contextualize their BP values within their daily lives and participate more equally in their follow-up consultations with their providers [23]. Patients who regularly used online health portals had a significantly greater interest in using websites and mobile phone apps to monitor and record their BP, weight, exercise, and medication usage data [24]. Patients with the most significant clinical need showed the highest engagement levels, and higher engagement levels were associated with a more significant BP reduction [19]. Additionally, the presence of an informal caregiver who received health information regarding the patient was found to increase patient engagement significantly [21]. In one study, patient engagement was promising for the first month but then fell off sharply during the next 2 months [15].

Patient Knowledge, Attitudes, and Behaviors

Compared to the usual care group, patient knowledge was significantly improved ($p < 0.05$) in patients using a telemedicine intervention [17]. Patients felt a greater sense of responsibility in monitoring their health and felt greater motivation to make and maintain lifestyle changes [18]. In older patients, e-Health literacy was positively associated with online portal usage and an interest in using health-tracking tools [18]. e-Health literacy scores were also positively associated with higher education and negatively associated with age [24].

Table 3 Summary characteristics and findings of the included studies

First author, year	Population/sample	Sample size	Design/data collection	Telemedicine intervention	Main findings
Aberger, 2014 [14]	Patients in renal transplant clinic within 700 bed urban hospital in the USA	66 post-transplant patients	Survey research using convenience sampling and self-reported data by patients via home electronic BP monitoring	Telemedicine system in which patients self-record BP values at home using an uploadable BP monitor. BP values are uploaded to a patient portal that is accessible to pharmacist as well as physician who can tailor treatment accordingly to BP values. Patient portal contains messaging platform that sends automated and tailored feedback messages to engage and reinforce patients	75% of patients enrolled in the study monitored their BP at least once and 69% of patients took 6 readings and obtained a BP average. Statistically significant reductions in average SBP and DBP readings upon 30 days and 180 days of study enrollment were observed
Bengtsson, 2018 [23]	Hypertension patients and their healthcare providers in 4 primary care centers in Sweden	20 patients and 7 healthcare providers	Qualitative and exploratory study design	8-week use of a mobile phone-based BP self-monitoring system that incorporates the following features: daily BP and pulse measurements, motivational messages that encourage maintenance of lifestyle changes, and graphs displaying self-recorded BP data	Patients demonstrate greater engagement in and contribution to follow-up consultations with their healthcare providers regarding their BP values after 8-week use of the mobile phone-based telemedicine intervention. Importantly, during follow-up visits, patients contextualized elevated or reduced BP readings based on what they were doing on the days those BP readings were taken and therefore assumed a more active role in the interpretation and management of their hypertension
Cottrell, 2015 [15]	Hypertensive patients enrolled in one of four national telemedicine-based hypertension protocols in England	2963 patients	Patient registration data and data entered by patients	Mobile phone-based telemedicine platform (Florence) to which patients can upload self-recorded BP values, and receive reminder text messages about uploading BP data as well as messages on next steps to take if their BP readings are outside an acceptable range. In this study, patients are enrolled in one of four national telemedicine initiatives/protocols in which protocol success criteria is defined by how engaged patients are in BP monitoring based on the number of text messages they send via Florence in a defined period of time	Patient engagement in protocols was satisfactory in the first month; however, engagement rapidly declined over the following 2 months. As patient medical records were not examined and patient interviews were not conducted, it was not possible to gain clarity on the specific reasons why patient engagement declined over time

Table 3 (continued)

First author, year	Population/sample	Sample size	Design/data collection	Telemedicine intervention	Main findings
Frias, 2017 [16]	Patients with uncontrolled type 2 diabetes and hypertension in the USA	109 patients	12-week, open-label, prospective, cluster-randomized controlled study	Digital medicine offering (DMO) that consists of an ingestible pill with a sensor, adhesive skin patch that collects medication usage data, as well as a mobile app that compiles medication adherence data from skin patch. Providers can view adherence data via a web portal and make medication adjustments as needed. DMO use outcomes were evaluated at 4 weeks and 12 weeks	91% of patients reported that using the DMO data was useful to manage their health and 93% reported that the data improved their health. 91% stated that sharing data with their provider gave them a better understanding of their care plan. Patient engagement was evaluated by a 10 question patient activation measure (PAM). Participants in the DMO group had a nonsignificant greater increase in PAM scores compared to the control group While the DMO groups demonstrate greater reductions in SBP and HbA1c at weeks 4 and 12 compared with the control group, the SBP reduction at week 4 was the only statistically significant finding
Guo, 2017 [17]	Patients with atrial fibrillation in China. Hypertension was among the most common comorbidities in both the intervention and control groups	209 patients	Cluster randomized design study	Mobile atrial fibrillation (mAF) app that stores patient health records, automatically assesses stroke and bleeding risk and provides treatment regimen suggestions, offers educational modules on atrial fibrillation, and encourages patients to self-monitor their heart rate and BP	Statistically significant improvements seen in patients' knowledge on atrial fibrillation, adherence to drug therapy, anticoagulation satisfaction, quality of life, and self care
Hallberg, 2018 [18]	Patients with high BP and their treating healthcare providers in Sweden	20 patients and 7 healthcare providers	Face-to-face semi-structured interview	8-week use of a mobile phone-based BP self-monitoring system that incorporates the following features: daily BP and pulse measurements, motivational messages that encourage maintenance of lifestyle changes, and graphs displaying self-recorded BP data	The mobile phone-based BP monitoring system is viewed in a generally positive way by both patients and providers. Patients were more cognizant of how lifestyle modifications impacted their BP values and came into their follow-up visits better informed about their BP data. Patients assumed a more active role in the interpretation of their BP data when interacting with their provider and reported an increased motivation to make lifestyle changes and sustain these changes

Table 3 (continued)

First author, year	Population/sample	Sample size	Design/data collection	Telemedicine intervention	Main findings
Jean-Jacques, 2012 [26]	Black and white patients in a general internal medicine ambulatory care practice in Chicago	8919 eligible patients	Secondary data with time-series models	Health information technology (HIT) initiative within electronic health record that includes clinical reminders, decision support tools, and performance feedback directed to healthcare providers	Quality in patient care improved for 14 out of 17 measures for white patients and 10 out of 17 measures for black patients whose providers received HIT intervention. For one measure (blood pressure control in patients with diabetes), quality improved for black patients only. For one measure (blood pressure control for patients with hypertension), quality improved for neither group
Kaplan, 2017 [19]	Patients with two or more BP recordings	5115 patients	Single-arm retrospective observational study	Mobile health program (Hello Heart app) that allows patients to track their BP recordings, provides BP measurement reminders, and contains educational modules	2 weeks after initial download of the Hello Heart app, 74% of patients were still recording their BP, 45% were still recording at 4 weeks, 21% at 8 weeks, 6% at 16 weeks, and 1.9% at 22 weeks. Mean app visits were 15 times per week across the different subgroups. App visit to BP recording ratio was 3:1
Levine, 2018 [20]	Primary care patients with hypertension in the USA	1786 patients	Retrospective cohort study	Asynchronous virtual primary care visit occurring within 21 to 180 days following an in-person visit. During the virtual visit, the patient enters 5 blood pressure readings on a mobile-friendly website, notes medication adherence, reviews medication side effects, and can ask questions of their primary care clinician	Compared to usual care patients, patients who received virtual visits had reduced utilization of in-person primary care visits only. No significant difference was observed in SBP control between the experimental and control groups
Masi, 2012 [25]	Primary care providers in urban Federally Qualified Health Centers (FQHCs)	12 primary care providers	Prospective cohort study with a comparison group	12-session telehealth educational program for primary care providers that consisted of lectures by hypertension specialists and case presentations about patients with uncontrolled hypertension	Significant increase in primary care providers' mean hypertension knowledge test score as well as a significant increase in the mean self-assessed competency score upon completion of the 12-session curriculum
Piette, 2016 [21]	Patients with diabetes and/or hypertension in Bolivia	72 patients	Randomized trial	Weekly automated interactive voice response (IVR) calls that occur for up to 4 months to patients as the standard mHealth intervention group. Weekly IVR calls to patients coupled with IVR calls to informal caregivers as the mHealth + informal caregiver intervention group	Patients with an informal caregiver who also received IVR calls completed significantly more IVR calls than patients in the standard mHealth intervention group (62% vs 44% $p < 0.047$)

Table 3 (continued)

First author, year	Population/sample	Sample size	Design/data collection	Telemedicine intervention	Main findings
Price-Haywood, 2017 [24]	Adults 50 years or older with hypertension and/or diabetes in the USA	247 patients	Cross-sectional survey	MyOchsner online patient portal that is a part of the Ochsner Health System in Louisiana. Patient portal allows patients to check lab values, make healthcare appointments, and ask their providers medical questions. Patients were surveyed on their portal usage habits as well as general internet use and eHealth literacy	e-Health literacy was positively associated with MyOchsner portal usage and interest in health-tracking tools. Portal users had significantly greater interest in using mHealth interventions to track their health parameters such as blood pressure, weight, exercise, medication, and heart rate
Tobe, 2019 [22•]	Canadian First Nations people with uncontrolled hypertension	122 participants	Randomized controlled study	Active (hypertension management-specific) and passive (general healthcare) SMS text messages sent to participants twice a week	No difference was observed in BP reduction between the active and passive SMS groups. BP control was not improved by active SMS messages

Patient Satisfaction

In studies that assessed patient satisfaction with the telemedicine intervention [15–18, 23, 24], patients generally viewed the intervention positively. In one study, over 90% of the patients reported that the app was user-friendly and helpful [17]. In another study, patients reported that the intervention was a user-friendly tool and could enable healthcare providers to better understand the patient perspective [18]. Some suggestions that patients and healthcare workers had for improving the telemedicine-based intervention were making graphs easier to understand and tailoring the system according to personal preferences [18]. When comparing patients who used an online health portal with portal non-users, a significantly greater proportion of the portal users rated viewing lab results, checking health records for accuracy, and receiving test reminders as useful [24]. Some concerns among portal non-users about portal use were the privacy and security of their health data, not seeing the need for using the portal to manage their health and the lack of personalization in using technology [24]. Concerns about computer literacy, the difficulty of remembering passwords and logging into portal accounts, lack of technical support, provider availability for online appointment scheduling, and response times to medical messages were expressed by portal users [24]. In one study, the majority of patients who responded to a survey about the telemedicine intervention reported feeling more confident understanding their BP and taking their own BP measurements upon using the intervention [15].

Reduction in High Blood Pressure

Three studies reported statistically significant reductions in blood pressure levels upon using a telemedicine intervention [14, 16, 19]. In one study, statistically significant decreases in both average SBP and DBP readings were observed upon 30 days ($p < 0.01$) and 180 days of study enrollment ($p < 0.05$) [14]. In another study, the intervention group had a greater reduction in SBP at weeks 4 and 12 compared with the usual care group. However, the decline in SBP in week 4 was the only statistically significant finding [16]. In the third study, a statistically and clinically significant reduction in SBP was observed in less than 4 weeks, where 10% of the participants experienced a drop of at least 10 mm Hg in SBP ($p < 0.001$) [19]. On the other hand, two studies did not report significant differences in blood pressure levels upon using a telemedicine intervention [20, 22•] (Table 4).

Discussion

Previous studies that have examined the effects of telemedicine interventions on the management of hypertensive patients have primarily focused on changes in SBP and

Table 4 Differences in the blood pressure reduction between the intervention and control groups

First author, year	Changes in blood pressure between the telemedicine intervention and the control/standard care/usual care
Aberger, 2014 [14]	Baseline vs 30 days after intervention: significant decrease in SBP and DBP, 6.0 mm Hg and 3.0 mm Hg, respectively (p values < 0.01). Baseline vs 180 days after intervention: significant decrease in SBP and DBP, 6.6 mm Hg and 5.0 mm Hg, respectively (p values < 0.5)
Cottrell, 2015 [15]	BP control was achieved by only 5–22% of 1495 patients signed up to one of the three monitoring protocols. No data on exact or average changes in blood pressure
Frias, 2017 [16]	At week 4, the intervention resulted in a statistically greater SBP reduction than usual care (mean difference − 9.1, 95% CI − 14.0 to − 3.3 mm Hg) and sustained even more reduction at week 12
Kaplan, 2017 [19]	Blood pressure reduction was achieved for 22–25% of application users between weeks 4 and 22 compared to the baseline
Levine, 2018 [20]	There was no significant difference in systolic blood pressure (SBP) change from baseline, comparing the virtual visit and the usual care
Tobe, 2019 [22•]	There was no significant difference in systolic 0.8 (95% CI − 4.2 to 5.8 mm Hg) or diastolic − 1.0 (95% CI − 3.7 to 1.8 mm Hg, $p = 0.5$) blood pressure between groups from baseline to final stage

DBP values and general BP control. The effects of telemedicine interventions specifically on improving patient engagement among patients with hypertension are not sufficiently studied. Understanding how telemedicine interventions impact patient engagement can optimize patient care and patient outcomes among hypertensive patients. Thirteen studies out of the 775 initially identified studies were included in this systematic review. This systematic review aimed to synthesize the existing evidence on telemedicine's effects on improving patient engagement among patients with hypertension.

In the reviewed studies, communication with patients mainly took place through a mobile platform, specifically through smartphones, with nine out of thirteen studies utilizing some form of smartphone communication. The ubiquitous use of smartphones and the increasing number of health-monitoring apps, in particular, may hold promise for expanding the scope of telemedicine interventions. Mobile health (mHealth) allows for faster transmission of patient health data to healthcare providers, offers convenience to both patients and healthcare providers, and has beneficial impacts on chronic disease management [27]. Although more evidence for the efficacy and cost-effectiveness of mHealth interventions is needed, mHealth nonetheless remains very much at the forefront of telemedicine developments and technologies [28].

BP data in eight of the all included studies were self-reported by patients, and in two other studies were recorded in a clinical setting. When caring for hypertensive patients, BP measurements taken in the clinical setting can often be inadequate or misleading [29]. For this reason, home blood pressure monitoring (HBPM) can be advantageous in improving patient care and prime patients to assume a more active role in managing their condition. One of the included studies explicitly states that patients received training on using an automated sphygmomanometer [15]. It is unclear in most studies if patients were adequately trained on how to record their BP. Integrating educational modules into blood pressure monitoring apps with videos demonstrating how to adequately take BP measurements can empower patients by increasing their knowledge and self-sufficiency in managing their condition.

Several studies included a feedback mechanism to inform patients of their BP data and encourage them to take BP recordings. One such feedback mechanism was using graphs and figures to display BP data over time. Another was enthusiastic animations with positive reinforcement language immediately upon patient submission of a BP recording. Some of the feedback was in the form of automated responses, while some feedback consisted of tailored messages. These feedback systems are an important method of ensuring patient engagement on a continual basis with the telemedicine intervention. When patients receive reinforcement and confirmation that they are on track with their BP measurements and have access to their BP data over time in a graphical manner, they can evaluate the BP data within the context of their daily lives and adopt a more health-conscious mindset. It is unclear which feedback systems are the most effective in encouraging patients to manage and record their BP. More robust research is needed to gain a complete understanding of the characteristics of the most effective feedback systems for optimal patient engagement.

Three studies demonstrated an apparent increase in patient engagement upon using the telemedicine intervention. In these studies, patients contextualized their BP values within their daily lives and contributed more equally

to conversations with their health providers. Those with the greatest clinical need showed the highest engagement levels. However, one study noted that while engagement was promising for the first month, it fell off sharply during the following 2 months. It is essential to gain a complete understanding of the factors that drive patient engagement and how patient engagement manifests over the long run. A limitation of some of these studies was that the study duration was not very long. Although patient engagement increased during the study period, it is impossible to say if this increase in engagement would be sustainable over time.

Overall, in those studies which assessed patient satisfaction with the telemedicine intervention, patient satisfaction was generally high. Patients viewed the intervention as user-friendly. However, patients did have concerns about health data privacy and ease of use of the system. Concerns about the ease of use of the system were of note among the elderly population. It has been shown that eHealth literacy score is usually negatively associated with patient age [30]. However, many times, elderly patients have more morbidities and, because of issues such as poor mobility, have a greater need for what these telemedicine interventions can offer [31]. The simplification of telemedicine and mHealth interventions can potentially improve elderly engagement in the process of receiving care and providing feedback to healthcare providers.

Telemedicine interventions targeted at healthcare providers may also contribute to better outcomes in the treatment of hypertensive patients. Primary care providers who participated in a 12-session telemedicine-based hypertension education program experienced a statistically significant increase in both hypertension management knowledge and self-assessed competency [25]. Increasing provider knowledge and competency can allow for more nuanced monitoring of patients' BP values and encourage provider-directed education of hypertensive patients.

Limitations

The studies included in this review come from different patient populations and small settings from different countries. These sociodemographic and cultural heterogeneities threaten the generalizability of the findings from these studies. Besides, in some studies, the sample consisted of well-educated individuals who were more likely to use technology. Additionally, the heterogeneity of the telemedicine and mHealth interventions in different studies makes identifying the most proper and effective intervention more challenging.

Another limitation of this systematic literature review is that only studies published in English were included in the review. It is possible that relevant studies were missed during the screening process due to excluding non-English publications and limiting the search to four databases. Therefore, information and insights about the topic of interest may have been excluded from this review. Despite these limitations, this study provides a comprehensive understanding of the different dimensions of utilizing telemedicine to control BP.

Future of Telemedicine Systems

Telemedicine and the use of telemedicine technologies within the current and future healthcare climate remain more relevant than ever, mainly due to the advent of the COVID-19 pandemic. Due to social distancing measures during the pandemic, many services previously offered in-person were offered via a telehealth format, and governments and health providers provided additional expansion of telemedicine options and funding [32•]. For instance, private health providers began providing their telemedicine services to the public free of charge, and medium- to small-sized medtech companies provided their telemedicine platforms to public health providers [32•]. Telemedicine has proven to be a cost-effective and indispensable tool during the pandemic and will undoubtedly be here to stay in the long run. Interestingly, it seems that previous hesitations in adopting telemedicine offerings are changing, and governments are looking more favorably on the utility of telemedicine interventions. For example, in South Korea, since 2018, there have been many controversies about adopting telemedicine systems. However, during the COVID-19 pandemic, the Seoul National University Hospital began actively offering telemedicine services to COVID-19 patients [32•].

A concern moving forward with the more widespread adaptation of telemedicine systems is the privacy and security of patient data. As echoed by the findings of studies in this systematic review, patients are indeed concerned about the confidentiality of their health data, which can prevent them from engaging fully with telemedicine interventions. The concern of third-party advertiser access to patient health data is particularly of note. Additionally, during the COVID-19 pandemic, patient consent was overlooked for the sake of public interest and public health in some circumstances [32•]. With the ever-growing use and relevance of telemedicine interventions, it is paramount that patient privacy and confidentiality be strictly protected to offer patients a sense of privacy and security.

Conclusions

Because the majority of the studies reviewed were published less than 10 years ago, it appears that the implementation of telemedicine interventions to improve patient engagement among those with hypertension is relatively new. Although the findings show the significant impact of telemedicine in achieving clinical improvements and patient engagement

and communication, more is to be known about the effectiveness of different telemedicine initiatives, especially compared to in-person visits to healthcare providers. Studies on the cost-effectiveness of different telemedicine and mHealth interventions can help understand potential cost savings for patients, healthcare personnel, and healthcare organizations. Given that high BP is more common among the elderly, ensuring the use of user-friendly and simplistic approaches might increase patient engagement and improve communication between healthcare providers and patients. Moreover, additional support such as hotlines and translator services can potentially ensure the telemedicine intervention's acceptability among culturally and linguistically diverse communities.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s11906-022-01186-5.

Author Contribution All authors contributed to the research process in various forms, including original draft preparation, summarizing findings, writing, reviewing, and editing. AK conceptualized and designed the study, performed the database search, and outlined the manuscript. EQ and NA reviewed the studies, identified the relevant studies, and performed the data extraction.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This is a review of publicly available and published research papers. No human subject or identification data is collected or analyzed in this study.

References

Papers of particular interest, published recently, have been highlighted as:
• Of importance
•• Of major importance

1.•• Hollander JE, Carr BG. Virtually perfect? Telemedicine for COVID-19. N Engl J Med. 2020;382(18):1679–81. **This article highlights the importance of using different telemedicine approaches to minimize in-person interactions between healthcare professionals and patients during the COVID-19 pandemic.**
2.•• Smith AC, Thomas E, Snoswell CL, Haydon H, Mehrotra A, Clemensen J, et al. Telehealth for global emergencies: implications for coronavirus disease 2019 (COVID-19). J Telemed Telecare. 2020:1357633X20916567. **This article focuses on the use of telehealth during emergencies, highlights several barriers, and proposes several solutions to ensure the continuation of telehealth.**
3. World Health Organization. Telemedicine: opportunities and developments in member states. Report on the second global survey on eHealth: World Health Organization; 2010.
4. American Hospital Association. Fact sheet: telehealth. 2019.https://www.aha.org/system/files/2019-02/fact-sheet-telehealth-2-4-19.pdf. Accessed 22 May 2020.
5. World Health Organization. Global diffusion of eHealth: making universal health coverage achievable: report of the third global survey on eHealth. World Health Organization; 2017.
6. Centers for Disease Control and Prevention. Hypertension cascade: hypertension prevalence, treatment and control estimates among US adults aged 18 years and older applying the criteria from the American College of Cardiology and American Heart Association's 2017 hypertension guideline—NHANES 2013–2016. 2019.https://millionhearts.hhs.gov/data-reports/hypertension-prevalence.html. Accessed 22 May 2020.
7. Centers for Disease Control and Prevention. Facts about hypertension. 2020.https://www.cdc.gov/bloodpressure/facts.htm. Accessed 22 May 2020.
8. Kirkland EB, Heincelman M, Bishu KG, Schumann SO, Schreiner A, Axon RN, et al. Trends in healthcare expenditures among US adults with hypertension: national estimates, 2003–2014. J Am Heart Assoc. 2018;7(11):e008731.
9. Omboni S, Ferrari R. The role of telemedicine in hypertension management: focus on blood pressure telemonitoring. Curr Hypertens Rep. 2015;17(4):535. https://doi.org/10.1007/s11906-015-0535-3.
10. James J. Patient engagement. Health Affairs Health Policy Brief. 2013;14(10.1377).
11. Fix GM, VanDeusen LC, Bolton RE, Hill JN, Mueller N, LaVela SL, et al. Patient-centred care is a way of doing things: how healthcare employees conceptualize patient-centred care. Health Expect. 2018;21(1):300–7.
12. Phillips LS, Branch WT, Cook CB, Doyle JP, El-Kebbi IM, Gallina DL, et al. Clinical inertia. Ann Intern Med. 2001;135(9):825–34. https://doi.org/10.7326/0003-4819-135-9-200111060-00012.
13. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gøtzsche PC, Ioannidis JP, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. J Clin Epidemiol. 2009;62(10):e1–34.
14. Aberger EW, Migliozzi D, Follick MJ, Malick T, Ahern DK. Enhancing patient engagement and blood pressure management for renal transplant recipients via home electronic monitoring and web-enabled collaborative care. Telemed J E Health. 2014;20(9):850–4. https://doi.org/10.1089/tmj.2013.0317.
15. Cottrell E, Cox T, O'Connell P, Chambers R. Implementation of simple telehealth to manage hypertension in general practice: a service evaluation. BMC Fam Pract. 2015;16(1):83. https://doi.org/10.1186/s12875-015-0301-2.
16. Frias J, Virdi N, Raja P, Kim Y, Savage G, Osterberg L. Effectiveness of digital medicines to improve clinical outcomes in patients with uncontrolled hypertension and type 2 diabetes: prospective, open-label, cluster-randomized pilot clinical trial. J Med Internet Res. 2017;19(7): e246. https://doi.org/10.2196/jmir.7833.
17. Guo Y, Chen Y, Lane DA, Liu L, Wang Y, Lip GYH. Mobile health technology for atrial fibrillation management integrating decision support, education, and patient involvement: mAF app trial. Am J Med. 2017;130(12):1388–96 e6. https://doi.org/10.1016/j.amjmed.2017.07.003
18. Hallberg I, Ranerup A, Bengtsson U, Kjellgren K. Experiences, expectations and challenges of an interactive mobile phone-based system to support self-management of hypertension: patients' and professionals' perspectives. Patient Prefer Adherence. 2018;12:467–76. https://doi.org/10.2147/PPA.S157658.
19. Kaplan AL, Cohen ER, Zimlichman E. Improving patient engagement in self-measured blood pressure monitoring using

a mobile health technology. Health Inf Sci Syst. 2017;5(1):4. https://doi.org/10.1007/s13755-017-0026-9.
20. Levine DM, Dixon RF, Linder JA. Association of structured virtual visits for hypertension follow-up in primary care with blood pressure control and use of clinical services. J Gen Intern Med. 2018;33(11):1862–7. https://doi.org/10.1007/s11606-018-4375-0.
21. Piette JD, Marinec N, Janda K, Morgan E, Schantz K, Yujra AC, et al. Structured caregiver feedback enhances engagement and impact of mobile health support: a randomized trial in a lower-middle-income country. Telemed J E Health. 2016;22(4):261–8. https://doi.org/10.1089/tmj.2015.0099.
22.• Tobe SW, Yeates K, Campbell NRC, Maar MA, Perkins N, Liu PP, et al. Diagnosing hypertension in Indigenous Canadians (DREAM-GLOBAL): a randomized controlled trial to compare the effectiveness of short message service messaging for management of hypertension: main results J Clin Hypertens (Greenwich) 2019;21(1):29–36. https://doi.org/10.1111/jch.13434. **This article reports the results of a randomized controlled study on the effectiveness of active and passive text messages in blood pressure (BP) reduction.**
23. Bengtsson U, Kjellgren K, Hallberg I, Lundin M, Makitalo A. Patient contributions during primary care consultations for hypertension after self-reporting via a mobile phone self-management support system. Scand J Prim Health Care. 2018;36(1):70–9. https://doi.org/10.1080/02813432.2018.1426144.
24. Price-Haywood EG, Harden-Barrios J, Ulep R, Luo Q. eHealth literacy: patient engagement in identifying strategies to encourage use of patient portals among older adults. Popul Health Manag. 2017;20(6):486–94. https://doi.org/10.1089/pop.2016.0164.
25. Masi C, Hamlish T, Davis A, Bordenave K, Brown S, Perea B, et al. Using an established telehealth model to train urban primary care providers on hypertension management. J Clin Hypertens (Greenwich). 2012;14(1):45–50. https://doi.org/10.1111/j.1751-7176.2011.00559.x.
26. Jean-Jacques M, Persell SD, Thompson JA, Hasnain-Wynia R, Baker DW. Changes in disparities following the implementation of a health information technology-supported quality improvement initiative. J Gen Intern Med. 2012;27(1):71–7. https://doi.org/10.1007/s11606-011-1842-2.
27. Mirza F, Norris T, Stockdale R. Mobile technologies and the holistic management of chronic diseases. Health Informatics J. 2008;14(4):309–21.
28. Marcolino MS, Oliveira JAQ, D'Agostino M, Ribeiro AL, Alkmim MBM, Novillo-Ortiz D. The impact of mHealth interventions: systematic review of systematic reviews. JMIR mHealth and uHealth. 2018;6(1):e23.
29. Pickering TG, Miller NH, Ogedegbe G, Krakoff LR, Artinian NT, Goff D. Call to action on use and reimbursement for home blood pressure monitoring: executive summary. Hypertension. 2008;52(1):1-9. https://doi.org/10.1161/HYPERTENSIONAHA.107.189011
30. Kim H, Xie B. Health literacy in the eHealth era: a systematic review of the literature. Patient Educ Couns. 2017;100(6):1073–82. https://doi.org/10.1016/j.pec.2017.01.015.
31. Stronge AJ, Rogers WA, Fisk AD. Human factors considerations in implementing telemedicine systems to accommodate older adults. J Telemed Telecare. 2007;13(1):1–3.
32.• Vidal-Alaball J, Acosta-Roja R, Pastor Hernández N, Sanchez Luque U, Morrison D, Narejos Pérez S, et al. Telemedicine in the face of the COVID-19 pandemic. Aten Primaria. 2020;52(6):418–22. https://doi.org/10.1016/j.aprim.2020.04.003.