

Journal of Pharmacy Practice

The Impact of Clinical Pharmacist Managed Remote Patient Monitoring of Hypertension in the Ambulatory Care Setting

Journal:	<i>Journal of Pharmacy Practice</i>
Manuscript ID	Draft
Manuscript Type:	Original Research Article
Keywords:	ambulatory-care pharmacist, hypertension, remote monitoring
Abstract:	Background Effective hypertension management is critical to reducing negative cardiovascular outcomes. Remote patient monitoring (RPM) can improve hypertension management through increased self-efficacy with collection and analysis of patient-generated blood pressure data. Compared to standard hypertension management, RPM represents an opportunity for clinical pharmacists to more efficiently identify and address poorly controlled blood pressure. RPM provides continuous communication with the patient and real-time assessment of home blood pressure readings. Objective To assess the impact of RPM and blood pressure management by the ambulatory care clinical pharmacist. Methods Hypertension management by a clinical pharmacist using RPM was compared to conventional management by the primary care provider through a retrospective review of blood pressure measurements recorded for patients in each group. The primary outcomes were the mean reduction in blood pressure and the percentage of patients with controlled blood pressure less than 140/90 mmHg. Results At the end of the study period, a greater percentage of patients in the RPM group (88%) had controlled blood pressure compared to patients receiving SOC intervention (48%), $p < 0.0001$. Additionally, in comparison to the SOC group, the RPM group had a statistically significant reduction in systolic (-23.9 mmHg [95% CI +/-4.7]; $p = 0.003$) and diastolic (-13.3 mmHg [95% CI +/- 2.8]; $p = 0.005$) blood pressure. Conclusion RPM presents ambulatory care clinical pharmacists with a unique opportunity to impact the care of their patients. A meaningful improvement of blood pressure was observed in the RPM group compared to the group receiving conventional hypertension management.

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For Peer Review

The Impact of Clinical Pharmacist Managed Remote Patient Monitoring of Hypertension
in the Ambulatory Care Setting

ABSTRACT

Background

Effective hypertension management is critical to reducing negative cardiovascular outcomes. Remote patient monitoring (RPM) can improve hypertension management through increased self-efficacy with collection and analysis of patient-generated blood pressure data. Compared to standard hypertension management, RPM represents an opportunity for clinical pharmacists to more efficiently identify and address poorly controlled blood pressure. RPM provides continuous communication with the patient and real-time assessment of home blood pressure readings.

Objective

To assess the impact of RPM and blood pressure management by the ambulatory care clinical pharmacist.

Methods

Hypertension management by a clinical pharmacist using RPM was compared to conventional management by the primary care provider through a retrospective review of blood pressure measurements recorded for patients in each group. The primary

outcomes were the mean reduction in blood pressure and the percentage of patients with controlled blood pressure less than 140/90 mmHg.

Results

At the end of the study period, a greater percentage of patients in the RPM group (88%) had controlled blood pressure compared to patients receiving SOC intervention (48%), $p < 0.0001$. Additionally, in comparison to the SOC group, the RPM group had a statistically significant reduction in systolic (-23.9 mmHg [95% CI +/-4.7]; $p = 0.003$) and diastolic (-13.3 mmHg [95% CI +/- 2.8]; $p = 0.005$) blood pressure.

Conclusion

RPM presents ambulatory care clinical pharmacists with a unique opportunity to impact the care of their patients. A meaningful improvement of blood pressure was observed in the RPM group compared to the group receiving conventional hypertension management.

Keywords

Ambulatory-care Pharmacist, Hypertension, Remote Monitoring

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BACKGROUND

Hypertension is a chronic condition that affects 116 million or 47% of adults in the United States.¹ According to the 2017 American College of Cardiology and the American Heart Association hypertension guidelines, Stage 1 and Stage 2 hypertension are defined as blood pressure readings for systolic blood pressure (SBP)/diastolic blood pressure (DBP) of 130-139/80-89 mmHg and ³140/90 mmHg, respectively.²

Uncontrolled hypertension is a modifiable risk factor for all-cause mortality, yet in 2018 approximately 0.5 million deaths in the United States included hypertension as the contributory or primary cause.¹ The Centers for Disease Control and Prevention (CDC) reports only about one in four adults (24%) with hypertension are controlled indicating room for improvement in the delivery of hypertension management interventions.¹

The diagnosis and management of hypertension is often based on the measurement of blood pressure during a routine visit in a primary care clinic, however, blood pressure readings in the clinic can be higher than ambulatory blood pressure readings. Reliance on office blood pressure readings may lead to slow medication titration and delay in

overall blood pressure control, therefore, self-monitoring at home is often encouraged.³⁻

⁶ While home blood pressure monitoring (HBPM) is a validated approach for detecting and improving uncontrolled hypertension, it does have limitations, including a risk of device inaccuracy, affordability of HBPM devices, and reliability of patient report.³⁻⁶ An analysis of the reliability of simple self-reported HBPM readings discovered that patient-reported values are exceptionally variable and may not be useful in assessing hypertension control.⁷ Use of integrated Bluetooth technology and establishment of a device loaner program could improve accuracy of home blood pressure readings and ensure access to a greater proportion of patients.

While most patients with hypertension are managed by their primary care provider with conventional treatment practices (standard of care model (SOC)), pharmacist intervention has been shown to improve the management of hypertension in both the community and ambulatory setting.⁸⁻¹⁰ A meta-analysis published in the Journal of the American Heart Association demonstrated that pharmacists interventions may reduce SBP and DBP by an average of 7.6 mmHg and 3.9 mmHg, respectively, when

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3 compared to SOC.¹¹ A recent study published in the American Journal of Hypertension
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7 showed that, relative to the usual care model, pharmacist telemonitoring interventions
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10 reduced the incidence of cardiovascular events including myocardial infarction, stroke,
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13 heart failure, and death by approximately 50%. However, the study did not have enough
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17 power to detect a statistically significant difference.¹⁰
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24 Remote patient monitoring (RPM) involves the gathering of patient-measured
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28 physiologic data, such as blood pressure, and the transmission of this data to the
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31 healthcare team for analysis. Pharmacist home blood pressure measurement via RPM
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34 has the potential to produce a positive impact on patient's blood pressure control.¹²⁻¹³
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38 Most RPM platforms allow patients to monitor their blood pressure from home using
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42 Bluetooth enabled devices with automatic transmission of data for interpretation by the
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45 care team. Such services provide a model of care that expands access, especially to
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48 rural communities, and facilitates more effective patient-care team interactions.
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Pharmacists, practicing under collaborative practice agreement (CPA), have an emerging role in addressing the challenges to delivering effective hypertension care in the ambulatory care setting. The purpose of this study is to assess the impact of clinical pharmacist managed hypertension using RPM.

METHODS

The study was conducted within a single primary care clinic in Missoula, Montana. Encounters that occurred over a 10 month period as part of a PGY1 residency project were included in the analysis. Hypertension control was assessed by comparing a panel of patients managed by a clinical pharmacist under CPA using the RPM platform PatientOne¹⁴ in comparison to a SOC group, who had hypertension managed by the primary care provider. The SOC group had blood pressure readings taken via manual sphygmomanometer at clinic appointments.

A retrospective chart review was conducted to collect data for both study groups. Patients were identified via a report generated from the electronic medical record (EMR)

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3 to include those with new or historical diagnosis of hypertension and the most recent
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7 documented systolic blood pressure (SBP) of ≥ 140 mmHg and/or diastolic blood
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10 pressure (DPB) ≥ 90 mmHg. Patients were designated as receiving SOC if the PCP
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13 managed the patient through conventional methods. Patients were designated as
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17 receiving RPM if they were referred to clinical pharmacy for hypertension management
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20 and had at least one BP documented via the remote monitoring platform. Patients were
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23 referred to clinical pharmacy services directly by the PCP or via an automated referral
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27 program for patients with SBP ≥ 180 mmHg and/or DBP ≥ 100 mmHg.
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34 All patients enrolled in the RPM service were loaned a validated, automatic blood
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38 pressure monitor for home use. During the initial visit, each patient was educated on
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42 how to properly take blood pressure with the loaner device. Phone application set-up,
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45 account creation, and overview was also completed in-person at the time of the initial
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49 office visit. While Bluetooth connection with a smart phone or tablet was preferred,
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53 patients did have the ability to manually enter their blood pressure if the smart device
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was unable to support Bluetooth upload or if a patient was using the web-application from a computer.

Patients in the RPM group received daily text message reminders to check their blood pressure and answer brief questions regarding any potential symptoms of hypertension, medication side effects, and adherence to antihypertensive medications. Occasional educational messages focusing on lifestyle modifications and medication taking were sent to all patients in the RPM group. The RPM application also provided patients with a messaging function to efficiently communicate with their care team.

Once a patient was enrolled into the RPM service, a follow-up telehealth appointment was scheduled with the clinical pharmacist every two to four weeks, in accordance with the organization's hypertension clinical pathway, to review RPM data (Figure 1). Vital signs were transmitted to the RPM platform in real time which allowed the clinical pharmacist to interpret the data prior to the telehealth appointment. The pharmacist then had the ability to adjust medications and order appropriate labs for drug therapy

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3 monitoring through CPA. Elevated blood pressure readings (SBP ≥ 160 and/or DBP
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7 ≥ 100 mmHg) or positive responses to symptom screening questions generated alerts,
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10 allowing the clinical pharmacist to provide real-time intervention which was often
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13 conducted via the application's messaging system. An afterhours response advising
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17 the patient to contact the nurse-on-call or seek emergency evaluation was sent to
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20 patients following any positive symptoms screen or SBP ≥ 180 and/or DBP ≥ 120 mmHg
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23 recorded outside of normal clinic hours.
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31 The primary outcome was a comparison of the proportion of patients achieving blood
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34 pressure control at the final blood pressure measurement between the RPM group and
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37 the SOC group. Blood pressure control was defined as SBP/DBP (will refer to as simply
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40 BP for rest of manuscript) of $< 140/90$ mmHg per clinical quality measure CMS-165 set
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43 by the National Committee for Quality Assurance (NCQA). The secondary outcomes
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47 were the time to the first BP measurement of $< 140/90$ mmHg and the mean change in
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52 SBP and DBP between the two groups.
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The primary outcome was assessed using documented blood pressure readings from two separate encounters within the study assessment period. As patients in the RPM group had more frequent follow-up encounters with the pharmacist than patients in the SOC group had with the PCP, only blood pressure readings from encounters occurring approximately one and three months after enrollment were assessed. Patients in both groups who were found to have blood pressure meeting definition of control at the first assessment encounter or those who were lost to follow-up may have had only one blood pressure analyzed. Due to the nature of the RPM service, multiple home blood pressure readings were assessed at each follow-up encounter with the clinical pharmacist; therefore, the average of the available home blood pressure readings dating up to two weeks back was used for the analysis. For the SOC group, the last manual blood pressure documented in clinic was used for the analysis. The final blood pressure, or blood pressure average, from last encounter defined by the end of the study period for the patient and was compared to the baseline blood pressure at the initial visit.

STATISTICAL ANALYSIS

The percentage of patients controlled versus uncontrolled were analyzed using the chi-square method. A two-tailed t-test was used to analyze the mean change in SBP and DBP and the difference in the time to the first controlled BP measurement between the two groups. Only patients with at least one blood pressure measured after baseline were included in the analysis. Logistic regression analysis was conducted to identify predictors of blood pressure control in the patient population. Included in the regression analysis was the BP management service (RPM versus SOC) and any baseline categories that were significantly different between the two groups. Only variables that showed a significant correlation to BP control in a univariate analysis were included in the final multivariate regression model. For all statistical tests, $p < 0.05$ was considered statistically significant. Descriptive statistics, t-tests, and chi-squared analyses were performed using Microsoft Excel® (Redmond, WA). Logistic regression analysis was performed with MedCalc®.¹⁵

RESULTS

There were 212 patients retrospectively reviewed over the 10 month period (Figure 2). Of those, 51 patients were not considered eligible for inclusion for the following reasons: no formal documentation of hypertension per PCP, previous BP measurements were <140/90 mm Hg, blood pressure managed elsewhere, ie. cardiology, the initial blood pressure measurement was documented per patient report during a telehealth encounter, or the was PCP no longer practicing at primary clinic. Of the remaining 161 patients, 57 were referred to clinical pharmacy for RPM services and 104 continued under the care of the PCP meeting criteria for SOC management. At least one follow-up blood pressure was available for 48 patients in the RPM group and 46 patients in the SOC group. Nine patients referred to the clinical pharmacist were not included in the analysis. Four patients were lost to follow-up, three patients were unable to use the RPM platform, one patient requested blood pressure management by the PCP, and one patient changed providers.

Baseline characteristics of patients by study group are listed in Table I. The mean SBP and DBP at baseline was similar for both groups, with 151.9 mmHg [95% CI +/- 4.3] and

90.5 mmHg [95% CI +/- 3.5], and 153.2 mmHg [95% CI +/- 4.6] and 94.5 mmHg [95% CI +/- 3.0], in the SOC and RPM group, respectively. Patients in the RPM group were younger with a mean age of 51.7 years versus 60.5 years in the SOC group ($p=0.0078$). There was no difference in gender distribution between groups.

Patients in the SOC group were prescribed more antihypertensive medications at baseline compared to the RPM group (Figure 3). The most common antihypertensives utilized in the SOC group included an angiotensin converting enzyme inhibitor (27%), thiazide diuretic (20%), angiotensin receptor blocker (16%), calcium channel blocker (14%) or beta blocker (12%). Similarly, the intervention group commonly utilized an angiotensin receptor blocker (32%), angiotensin converting enzyme inhibitor (30%), thiazide diuretic (25%), no medication (25%), or calcium channel blocker (16%). More patients in the RPM group were not receiving antihypertensive therapy at baseline (25% versus 4%).

Patients in the RPM group had earlier follow-up BP assessment than did those in the SOC group. For the RPM group, the mean time to the first BP measurement after the index measurement was 30 days (SD 14.8 days). The second blood pressure measurement was available for 23 patients and was taken at a mean of 95 days (SD 43.7 days) after the index blood pressure. For the SOC group, the mean time to the first BP measurement after the index measurement was 63 days (SD 42.1 days). The second blood pressure measurement was available for 34 patients and was taken at a mean of 112 days (SD 35.5 days) after the index blood pressure.

By the end of the study, 88% of patients in the RPM group achieved blood pressure control, compared to 48% in the SOC group ($p<0.0001$). In the first sixty days, 79% of the patients in the RPM group achieved control, compared to 24% of patients in the SOC group (Figure 4). For those patients achieving BP control, the mean time to control was 36.8 days (SD 28.8 days) in the RPM group and 83.6 days (SD 52.3 days) in the SOC group ($p<0.0006$).

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4 The last measured BP, and the change from baseline, are shown in Table 3. The mean
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7 final SBP and DBP in the RPM group was 129.3 mmHg and 81.3 mmHg, which was
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10 lower than the SOC group with mean SPB and DBP of 142.9 mmHg and 83.9 mmHg,
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13 respectively. The difference in the SBP between the two groups was statistically
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16 significant ($p=0.0005$); however, DBP was not different between the two groups
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19 ($p=0.27$). Change in mean blood pressure from baseline to the final blood pressure was
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22 statistically significant in both arms ($p<0.05$). The mean change in SBP and DBP was
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25 greater in the RPM group compared to SOC, with reduction in SBP of -23.9 mmHg vs -
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28 9.0 mmHg ($p=0.0003$) and reduction in DBP of -13.3 mmHg vs -6.7 mmHg ($p=0.0045$).
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38 In the univariate logistic regression analysis, only the type of BP management service
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41 (RPM or SOC) and the number of antihypertensive medications at baseline were
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44 significant predictors of BP control (Table 4). In the multivariate analysis, only the type
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47 of BP management service remained as an independent predictor of blood pressure
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DISCUSSION

As demonstrated in prior studies, our results corroborate data that show pharmacist collaborative care models can significantly improve blood pressure control after 3 months.^{6,8-12} While self-monitoring of blood pressure at home with telehealth follow-up has been shown to help improve blood pressure control, additional studies show this method may result in inaccurate report of blood pressure readings, which can lead to a false sense of control or inappropriate medication adjustments.^{3-5, 10-12} The current study sought to address limitations of standard telemonitoring programs, showing benefit of clinical pharmacy-led RPM services using Bluetooth technology that allows for automatic upload of blood pressure readings. Moreover, such technology allows pharmacists to closely monitor patients home blood pressure readings and make timely and efficient titration of antihypertensives in order to achieve a patient's goal blood pressure.

In comparison to the SOC group, the RPM group in this study had a greater reduction in both SBP and DBP and more patients achieved blood pressure control by the end of the

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3 study. The time to achieve control was significantly shorter in the RPM group compared
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7 to the SOC group. In addition to improved blood pressure control, the RPM group in this
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10 study had fewer patients lost to follow-up in comparison to the SOC group that could
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13 have been related to improved access and patient-provider interaction. This model is
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16 especially important in circumstances, such as the current global pandemic, when
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19 attending office visits may increase risk of transmission of an infectious disease. The
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22 potential lack of access to adequate care and timely follow-up increases risk of negative
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25 cardiovascular outcomes, including stroke or myocardial infarction. More studies need
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28 to be conducted to assess the effect of pharmacist-led RPM on access to care and
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31 cardiovascular outcomes.
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42 There are limitations to note with the present study. The first is a small sample size due
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45 to loss to follow-up in the SOC group. Additionally, the study was conducted in a single
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48 primary care clinic, and as such reflects practice and the practitioners within that center
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51 of practice; the results may not be the same in all primary care clinics. The study was
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54 conducted during the COVID-19 pandemic that may have influenced the loss to follow
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up and lack of motivation to gain control of blood pressure within the SOC group.

Patients enrolled in RPM were managed through telehealth services including telephone and computer, however they had to be present in the clinic during their initial enrollment into the program, and when deemed appropriate. Due to limitations of self-report, home blood pressure readings reported to the PCP were not included in the analysis for the SOC group and therefore the effects of “white coat hypertension” for some of these patients could have affected results in that group. The RPM group was younger and took fewer antihypertensives than the SOC group; however, it is important to note that neither factor was an independent predictor of blood pressure control in the multivariate logistic regression analysis. Finally, RPM requires patients to have the ability to utilize technology including but not limited to smartphone, computer, or tablet application which did lead to a small number of dropouts from the RPM group

CONCLUSION

According to the results of this study, pharmacist-led RPM service resulted in substantial blood pressure reduction by the end of the study period. The integration of

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3 pharmacists into the primary care model has provided a positive impact on chronic
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7 disease state management by providing lifestyle counseling, medication reconciliation,
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10 addressing medication adherence, and adjusting drug therapies. Achieving controlled
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13 blood pressure has the potential to result in clinically important effects by reducing
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17 cardiovascular outcomes and improving quality of life. It would be beneficial to further
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20 expand the study to assess outcomes over a longer period of time in a larger population
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Table 1. Baseline characteristics of patients with at least one blood pressure measurement.

Measures	SOC	RPM	p-value
Total Sample Size	46	48	
Males, No (%)	21 (46%)	20 (42%)	0.70

Females, No (%)	25 (54%)	28 (58%)	0.70
Age, All ,Mean (SD)	60.5 (16.4)	51.7 (15.1)	0.008
SBP, All, Mean [95% CI] (mmHg)	151.9 [±4.3]	153.23 [±4.6]	0.67
DBP, All, Mean [95% CI]	90.5 [±3.5]	94.5 [±3.0]	0.08
Antihypertensive Medications, Mean	2.0	1.2	<0.0001

Abbreviations: SOC, standard of care; RPM, remote patient monitoring; SD, standard deviation; 95% CI, 95% confidence interval; SBP, systolic blood pressure; DBP, diastolic blood pressure

Table 2. Percentage of patients with controlled BP at the end of the study and mean reduction in SBP and DBP.

	SOC	RPM	p-value
Total Sample Size	46	48	
Controlled, No (%)	22 (48%)	42 (88%)	<0.0001
Uncontrolled, no (%)	24 (52%)	6 (12%)	
SBP, All, Mean [95% CI] (mmHg)	142.9 [± 6.3]	129.3 [±3.9]	0.0005
DBP, All, Mean [95% CI] (mmHg)	83.9 [± 3.7]	81.3 [±2.5]	0.27

Change SBP, All, Mean [95% CI]	-9.0 [+/- 6.5]	-23.9 [+/- 4.7]	0.0003
(mmHg)			
Change DBP, All, Mean [95% CI]	-6.7 [+/- 3.6]	-13.3 [+/- 2.8]	0.005
(mmHg)			

Abbreviations: SOC, standard of care; RPM, remote patient monitoring; 95% CI, 95% confidence interval; SBP, systolic blood pressure; DBP, diastolic blood pressure

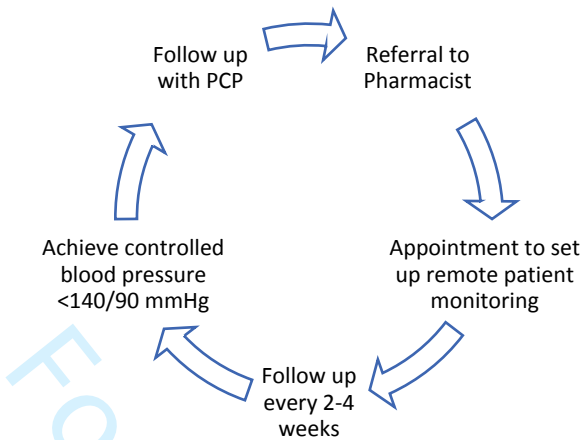
Table 3. Logistic regression analysis to identify independent predictors of blood pressure control.

Variable	Univariate analysis	Multivariate analysis		
	p-value	Odds Ratio	95% CI	p-value
Age	0.81	--	--	--
DBP	0.67	--	--	--
Baseline Number of BP medications	0.0049	1.38	0.8 – 2.4	p=0.25
Type of BP management (SOC or RPM)	<0.0001	5.95	2.0 – 17.9	p=0.015

Abbreviations: DBP, diastolic blood pressure; BP, blood pressure; SOC, standard of care; RPM, remote patient monitoring

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Figure 1. The clinical pharmacist led RPM patient care process.



Abbreviations RPM, remote patient monitoring

Figure 2. Patient enrollment in SOC or RPM service.

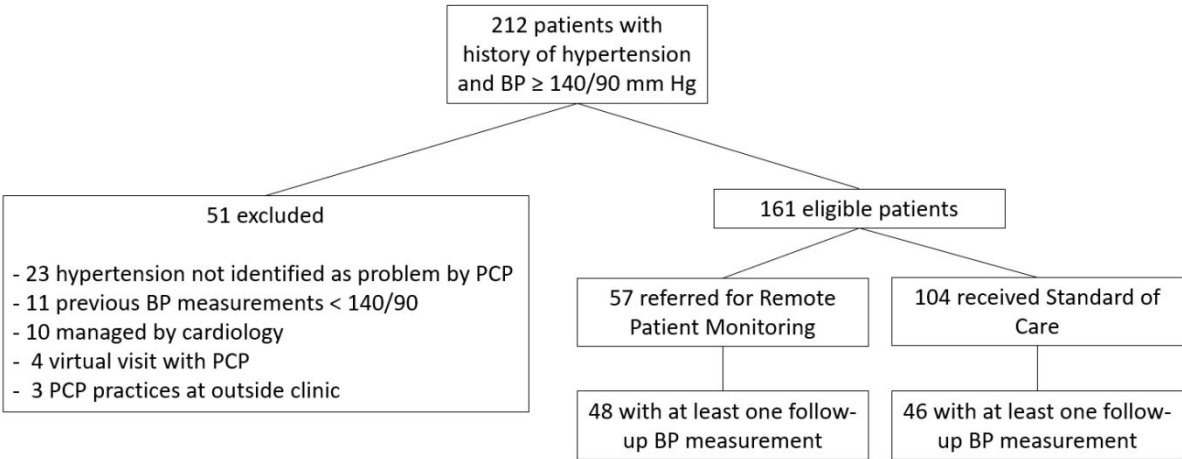
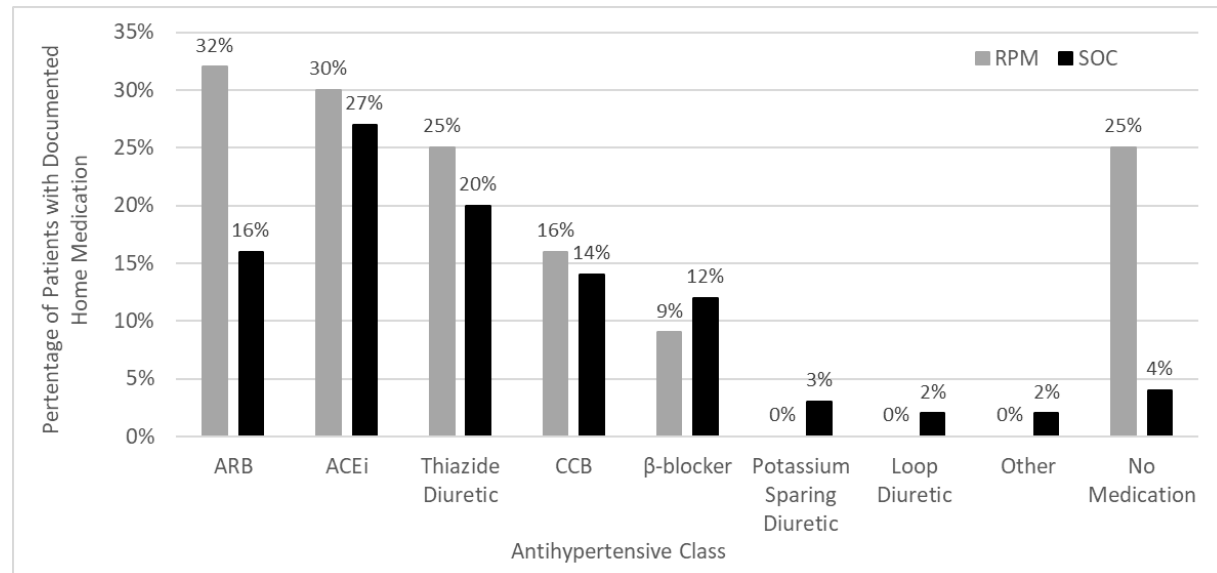
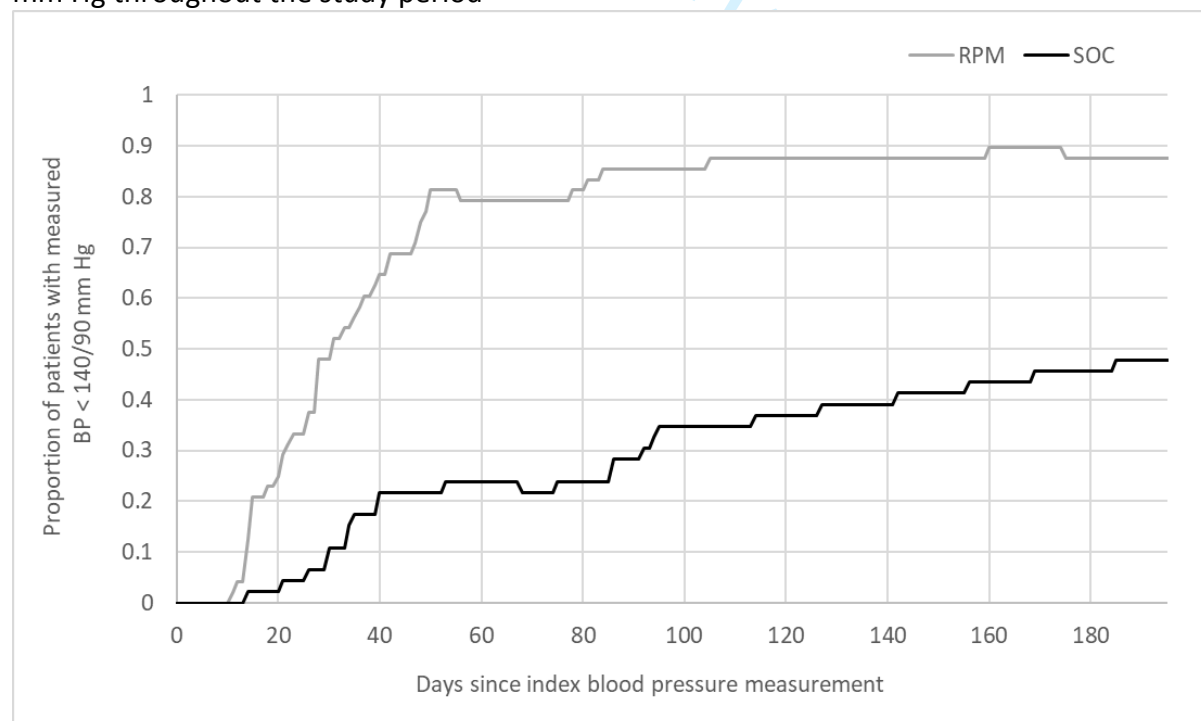


Figure 3. Baseline antihypertensives utilized in study groups.

Abbreviations: RPM, remote patient monitoring; SOC, standard of care; ARB, angiotensin receptor blocker; ACEi, angiotensin converting enzyme inhibitor; CCB, calcium channel blocker

Figure 4. Proportion of patients in the SOC and RPM groups with measured BP < 140/90 mm Hg throughout the study period

Abbreviations: RPM, remote patient moitoring; SOC, standard of care

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