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# Home blood pressure monitoring, secure electronic messaging and medication intensification for improving hypertension control

## A mediation analysis

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### Keywords

Personal health records, patient-provider communication, telemedicine and telehealth, remote monitoring, internet portal, patient self-care, home care and e-health

### Summary

**Objective:** We evaluated the role of home monitoring, communication with pharmacists, medication intensification, medication adherence and lifestyle factors in contributing to the effectiveness of an intervention to improve blood pressure control in patients with uncontrolled essential hypertension.

**Methods:** We performed a mediation analysis of a published randomized trial based on the Chronic Care Model delivered over a secure patient website from June 2005 to December 2007. Study arms analyzed included usual care with a home blood pressure monitor and usual care with home blood pressure monitor and web-based pharmacist care. Mediator measures included secure messaging and telephone encounters; home blood pressure monitoring; medications intensification and adherence and lifestyle factors. Overall fidelity to the Chronic Care Model was assessed with the Patient Assessment of Chronic Care (PACIC) instrument. The primary outcome was percent of participants with blood pressure (BP) <140/90 mm Hg.

**Results:** At 12 months follow-up, patients in the web-based pharmacist care group were more likely to have BP <140/90 mm Hg (55%) compared to patients in the group with home blood pressure monitors only (37%) ( $p = 0.001$ ). Home blood pressure monitoring accounted for 30.3% of the intervention effect, secure electronic messaging accounted for 96%, and medication intensification for 29.3%. Medication adherence and self-report of fruit and vegetable intake and weight change were not different between the two study groups. The PACIC score accounted for 22.0 % of the main intervention effect.

**Conclusions:** The effect of web-based pharmacist care on improved blood pressure control was explained in part through a combination of home blood pressure monitoring, secure messaging, and antihypertensive medication intensification.

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## 1. Background

Treatment of hypertension decreases cardiovascular-related mortality, stroke, myocardial infarction, renal failure, and all-cause mortality. Only about one half of those with hypertension, however, have blood pressure below target goals. Low medication adherence, lack of home blood pressure monitoring and failure of providers to intensify antihypertensive medication therapy have been identified as key barriers to improving hypertension control [1]. Providers fail to intensify medication regimens in over half of the visits where patients had blood pressure over 140/90 mm Hg [2] and about half of patients prescribed an antihypertensive stop taking it within one year [3]. Recent trials using pharmacist case management interventions variously targeting home blood pressure monitoring, adherence and medication intensification have shown improvements in blood pressure control [4-7].

Web-based communications combined with pharmacist care management provide an opportunity to shift the focus in hypertension care away from the challenges of inertia in the clinic visit and toward supporting home monitoring and ongoing patient needs for blood pressure management. We developed a web-based pharmacist intervention focused on improving medication treatment, medication adherence and lifestyle changes for blood pressure control among patients with essential hypertension. As we previously reported, the pharmacist group improved blood pressure control relative to a group receiving usual care and a home blood pressure monitor as well as the usual care group [4].

## 2. Objective

In this study, we hypothesized that the possible mechanism for achieving better blood pressure control in the pharmacist group was through the use of home blood pressure monitoring and pharmacist communication leading to a combination of improvements in medication intensification, medication adherence and lifestyle factors. We tested the mediation of these potentially modifiable factors in the group with pharmacist communication (BPM-Pharm) compared to the group with blood pressure monitors only (BPM). We limited our analysis to the BPM compared to the BPM-Pharm group since outcomes were similar in the usual care group and BPM groups compared to the BPM-Pharm group [4] and we had self-report of home blood pressure frequency only in the BPM and BPM-Pharm groups. The usual care group was not part of the analysis.

## 3. Methods

### Setting and Participants

Group Health Cooperative (Group Health) is an integrated health care system with 640,000 enrollees in Washington State. The majority of Group Health's enrollees receive care through a closed group practice which has a commercially available electronic medical record (EMR, EpicCare) integrated with the services of a patient website ([www.ghc.org](http://www.ghc.org)). The services of the patient website included the ability to refill medications, make appointments, view portions of the EMR and use secure messaging to communicate with healthcare providers. Prior to and throughout the study period, all Group Health physicians were given an incentive of 5\$ per message beyond their salary to encourage electronic messaging. Group Health did not consider this a reimbursement and the incentive was not related to the study [8]. From June 2005 to December 2007, we recruited patients from 10 Group Health primary clinics. Institutional Review Board at Group Health approved the study. For a detailed description of study methods, see Green et al. [9].

### Patients

Using the EMR, we identified patients aged 25 to 75 years with a hypertension diagnosis and taking antihypertensive medications, with no diagnoses of diabetes, cardiovascular or renal disease, or other serious conditions. Research assistants telephoned potential participants to confirm eligibility

which included access to the Web, an e-mail address and willingness to obtain all their antihypertensive medications at Group Health–owned pharmacies. Eligible and willing patients were invited to 2 screening visits at their clinic in which a research assistant measured BP using the validated Omron Hem-705-CP (Omron Healthcare, Kyoto, Japan) upper arm automated monitor [10, 11]. If mean diastolic BP (last 2 of 3 BP recordings, with the first measurement dropped) was between 90 and 109 mmHg or mean systolic BP was between 140 and 199 mmHg at both screening visits, the participant was eligible for the study and written informed consent was obtained. In accordance with the requirements set by Group Health Human Subjects Review Committee, study staff arranged follow-up care for patients with blood pressures above these ranges.

Baseline height, weight, and self-reported data also were obtained prior to randomization. Randomized patients attended 1 more study-related clinic visit at 12 months.

## Randomization and Intervention

Before randomization, all participants were trained and registered to use Group Health's secure patient website if they had not already done so. After obtaining informed consent and confirming eligibility, patients underwent single-blind block randomization to ensure balance within medical centers and baseline systolic BP measures. Participants were randomized to one of three groups; usual care; usual care with home blood pressure monitor (BPM); or pharmacists assisted care with home blood pressure monitor (BPM-Pharm) delivered over the patient website. As previously noted, we limited our analysis to the BPM compared to the BPM-Pharm group.

## Intervention

The intervention targeted the six domains of Wagner's Chronic Care Model including evidence-based decision and self-management support, clinical information systems, delivery system redesign, health care organization, and community resources (► Figure 1) [12]. The trial was designed to reduce systolic and diastolic BP and increase the percentage of patients with controlled BP (<140 mm Hg systolic and <90 mm Hg diastolic).

## Home BP Monitoring Group

Patients in both the BPM and BPM-Pharm interventions were given a home BP monitor (Omron-Hem-705-CP), with the cuff size based on upper arm measurements [10, 11] and training on its use. They were instructed to use this monitor to check their BP at least 2 days per week with 2 measurements each time. They were told the goal for average home systolic and diastolic BP was 135 and 85 mm Hg or less, respectively, and lower than the goal for clinic measurements for systolic and diastolic BP of less than 140 and 90 mm Hg [13].

## Home BP Monitoring and web-based Pharmacist Care

Three Group Health clinical pharmacists performed all interventions for the group receiving home BP monitoring and web-based pharmacist care. The social cognitive model was used as a framework for behavior change (both medication adherence and lifestyle changes) [14].

After welcoming the patient to the study through a secure electronic message, the pharmacists arranged a one-time telephone visit to obtain a more detailed medication history, review allergies and intolerances and cardiovascular risk factors. At the end of the phone call, the pharmacists reviewed the following five components of the action plan with the patient and documented these in the medical record and in a secure message to patients: instructions for home BP monitoring; a list of current medications; at least 1 patient-selected lifestyle goal(s) from the list in the Group Health hypertension pamphlet (e.g. increasing physical activity, fruit and vegetable intake, weight loss); recommended medication changes based on the stepped medication protocols; and the follow-up plan. Each patient and his or her physician received an electronic copy of the action plan.

Planned communications with patients occurred through secure messaging over the patient website at least once every two weeks until blood pressure was controlled (average home BP <135/85

mm Hg) and as needed thereafter with a minimum of every 2 weeks for first two months of the study, monthly in months 4 through 6 and every three months for last six months. Messages could be as frequent as requested by participant or pharmacist. At each communication, patients were asked to provide home blood pressure measurements and concerns about medications and progress towards lifestyle goal(s). Patients were encouraged to collaborate with their pharmacist to update their action plan. All secure messages with patients and pharmacists communications with physicians were part of the EMR. The pharmacist made medication changes based on treatment protocols and had formal prescriptive authority as approved by the state medical board to make guideline-based changes. The pharmacists had additional protocols for laboratory testing (including baseline electrocardiograms if needed) and follow-up care. If any abnormality of clinical concern arises, the pharmacist notified the physician and requested instructions for follow-up management.

Based on the intended processes of the intervention and prior literature, we developed a hypothesized mediation model for the intervention (► Figure 2). In this model, the intervention was outreach communications by a clinical pharmacist to patients through secure messaging or over the phone. The intervention was then mediated through two steps. In step 1, patients measured home blood pressures and had ongoing communications with pharmacists over the phone and through secure messaging. This led to step 2 involving a combination of greater medication intensification and adherence and one or more changes in lifestyle factors (fruit and vegetable intake, exercise or weight loss) on the path to better control of hypertension. In this model, secure messaging and telephone encounters occurred as both intervention components (pharmacist outreach) and as mediators in the model (ongoing communications between pharmacists and patients). Since we were unable to create separate intervention and mediator measures for these communications, we include one overall measure recognizing it as a combined determination of intervention fidelity and mediation.

## Blinded Outcome Assessments

At the 12-month follow-up visit at the patient's clinic, trained research assistants blinded to the patient's study group measured BP using the same protocol as at baseline. Patients also filled out a 12-month follow-up questionnaire, which collected home blood pressure monitor use, lifestyle factors and the Patient Assessment of Chronic Illness Care.

## Measures

### Home Blood Pressure Measurement

We assessed frequency of home blood pressure monitoring through self-report on the 12 month follow-up survey. The survey item asked participants to report the average frequency of measuring blood pressure at home over the prior 12 months. Responses ranged over 10 categories from no measurement to 10 or more times week.

### Secure Messaging Threads and Telephone Encounters

Secure message use was measured by the number of message threads between providers (physicians, nurses or pharmacists) and patients. A message thread was defined as an initial message sent by either the patient or the provider and the series of subsequent replies from both parties. Patients or providers could initiate a thread. A provider initiated thread was only counted if a patient read one or more messages in the thread [15]. Since we were unable to determine which communications were related to hypertension care, we measured all secure messages and telephone encounters with healthcare providers (e.g. physicians, pharmacists, nurses) during the study period for each patient.

### Medication Intensity

We used automated medication ordering and pharmacy fill data to measure medication intensification based on the approach of Schmittiel et al. [16]. Intensification was a continuous measure defined as the total number of the following 3 occurrences: an increase in the number of drug classes; an increase in the daily dosage of at least 1 ongoing drug class; or a switch to a medication in a different drug class. Twelve medication classes were included for antihypertensive medications (beta

blockers; ACE inhibitors/angiotensin receptor blockers; peripheral alpha-1 blockers; loop diuretics; direct potassium sparing diuretics; thiazide diuretics; central alpha 2 receptor agonists; direct vasodilators; dihydropyridine calcium channel blockers; nondihydropyridine calcium channel blockers; selective aldosterone blockers; renin inhibitors). Combination pills such as lisinopril/hydrochlorothiazide were included in both classes.

### Medication Adherence

We used automated medication ordering and pharmacy fill data for the prescription medication gap measure developed by Karter et al. [17]. Proportion of time with sufficient medication was calculated for each anti-hypertensive medication prescribed at the time of randomization and for new medications prescribed during the study period. This measure includes gaps for newly prescribed medications as well as ongoing medications. For newly prescribed medications, the measure includes medications prescribed but never filled (i.e. not picked up by patients) and medications which are filled once but are not refilled. Follow-up of the antihypertensive therapy continued until the first of the following: end of the 12 month study period or provider ordered the medication to be discontinued in the EMR. For patients prescribed multiple antihypertensive medications, a summary of the medication gap was calculated based on the combined total days prescribed antihypertensives. Adherence was measured as a dichotomous variable with the proportion of time with sufficient medication equal to or above 0.80 defined as adherent, consistent with the literature [18].

### Lifestyle Factors

We assessed three lifestyle factors through self-report. Physical activity was measured through the Godin Weekly Leisure-Time Exercise Questionnaire, which determines an individual's weekly metabolic equivalents based on self-report of the frequency of strenuous, moderate, and mild leisure-time activity of at least 15 minutes. Prior studies confirmed the validity and reliability of the questionnaire [19]. Fruit and vegetable consumption was assessed with a single item measure from Beresford et al. Participants estimate average total number of fruits and vegetables in a day from 0 to 11 servings [20]. Weight was measured at baseline and at a 12 months follow-up study visit with a validated electronic scale.

### Patient Assessment of Hypertension Care

We assessed fidelity of the intervention to the Chronic Care Model using the Patient Assessment of Chronic Illness Care (PACIC) [21]. The PACIC tool collects patient-reported actions and care congruent with five domains of the Chronic Care Model: patient activation, delivery system design/decision support, goal setting, problem solving, and follow-up. Validation of the tool has shown that each domain has good internal consistency for brief scales and moderate test/re-test reliability ( $r = 0.58$  over three months) [22]. We are not aware of prior studies defining a clinical meaningful difference in PACIC scores. In analyses we applied the PACIC only to those individuals who reported receiving care for hypertension in the prior 12 months by a pharmacist, primary provider, or other physician.

Ethnicity, education, income, employment, and tobacco use were collected from the baseline survey. Age and gender were collected from the electronic medical record.

### Statistics

Since the usual care group and BPM had similar blood pressure outcomes in the trial and self-reported frequency of home blood pressure monitoring were available only for the BPM and BPM-Pharm groups, we limited our analysis on comparing the BPM and BPM-Pharm groups. We used the a priori model of mediation (► Figure 2) and the three step method for defining a mediator proposed by Baron and Kenny [23]. Step 1 tested an association between blood pressure outcome and intervention group at 12 months using modified Poisson regression [24] adjusting for sex, baseline systolic BP, baseline body mass index (BMI), already having a home BP monitor before the trial, clinic, and all baseline mediator values. Step 2 tested for an association between the mediator factors and intervention group using an unadjusted chi-squared score test. If both associations were significant, then Step 3 assessed whether the association between blood pressure outcome and treatment



group was attenuated after adjusting for the mediator factor of interest and other adjustment variables in Step 1. This attenuation of the effect is calculated as

$$100 * (\log(\text{Relative Risk without mediator}) - \log(\text{Relative Risk with mediator})) / \log(\text{Relative Risk without mediator}).$$

If significant associations are found in steps 1 and 2, and the intervention effect is attenuated by the factor in step 3, then the factor was a mediator of the association between the BP outcome and the intervention.

## 4. Results

Among the 778 enrolled in the trial, 258 were randomized to usual care (excluded from current analysis), 259 to BPM and 261 to BPM-Pharm (►Figure 3). Thirteen were lost to follow-up in the BPM group and 24 in BPM-Pharm group with 246 completing follow-up 12 month visit in BPM group and 237 in BPM-Pharm group. An additional 49 individuals from the BPM group and 51 from the BPM group were excluded, from the analysis because they disenrolled from GH during the follow-up period ( $n = 4$  BPM,  $n = 5$  BPM-Pharm) or were missing data for one or more mediator variables ( $n = 45$  BPM,  $n = 46$  BPM-Pharm) leaving 197 in the BPM group and 186 in the BPM-Pharm group for mediator analysis. The BPM and BPM-Pharm groups were similar in age, and racial and ethnic distribution. More women were in the BPM group (55.3%) compared to the BPM-Pharm group (44.1%,  $p = 0.028$ ) (►Table 1).

At 12 months follow-up, patients in BPM-Pharm group were more likely to have BP < 140/90 mmHg (55%) compared to patients in the BPM group (37%) ( $p = 0.001$ ). Home blood pressure monitoring was higher in the BPM-Pharm group compared to the BPM group ( $p < 0.001$ ). Secure messaging and phone encounters with Group Health providers were the same in both groups at baseline (the year prior to the intervention) (►Table 1). During the intervention period, the BPM-Pharm group had substantially more secure message threads compared to BPM group (BPM-Pharm mean 25.4; BPM mean 2.9,  $p < 0.001$ ) (►Table 2). Most of the secure message threads in the BPM-Pharm group were provider initiated (mean 20.4). Phone visits were also higher in the BPM-Pharm group (BPM-Pharm mean 5.3; BPM mean 3.1  $p < 0.001$ ). There were no differences between treatment groups for primary care, specialty care, or emergency care encounters (►Table 2); these were deemed to not be mediators following Step 2 of the mediator assessment.

At baseline, the mean number of antihypertensive medications was the same in the two groups (►Table 1). In the follow-up period, the BPM-Pharm group had more mean medication intensification events compared to BPM group (1.1 vs 0.6  $p < 0.001$ ). Medication adherence was high in both groups at baseline (95.4% for BPM, 90.3 BPM-Pharm;  $p = 0.08$ ) (►Table 1). All antihypertensive medications ordered by providers were dispensed to patients (primary adherence) in both groups during the intervention. Ongoing or secondary adherence did not change significantly during the intervention for the BPM group compared to the pharmacist group. Fruit and vegetable intake, physical activity and weight were similar at baseline in the two groups (►Table 1) and did not change significantly during the intervention (►Table 2).

PACIC scores were similar at baseline between the two study groups (►Table 1). Follow-up scores at 12 months were higher in the BPM-Pharm group compared to the BPM group (BPM-Pharm mean 3.3; BPM mean 2.5,  $p < 0.001$ ). Compared with the BPM group, the BPM-Pharm group had higher scores in all five subscales of the PACIC ( $p < 0.001$  for all subscales).

## Mediation Testing

►Table 3 shows the Step 3 mediator evaluation starting with the main effect of the intervention in the BPM vs BPM-Pharm group (RR 1.50; 1.20, 1.89) adjusting for baseline variables only (no mediators). Subsequent rows show the attenuation of the main intervention effect by the addition of each mediator to the model. Although medication adherence, weight change and fruit and vegetable intake were not associated with BPM-Pharm group compared to BPM group (Step 2), we included these variables in ►Table 3 since they were hypothesized to be important drivers of the intervention effects. The percent reduction of the main effect is estimated by the difference between the main ad-



justed effect (RR 1.50) and the RR with the inclusion of a mediator. The amount of home blood pressure monitor use accounted for 30.3% of the intervention effect. Total messaging contacts (SM and telephone), for example, accounted for 100.0% of the intervention effect. Medication intensification is a modest mediator, accounting for 29.3% of the intervention effect. The PACIC score, which measured intervention fidelity or the tasks and processes concordant with the intervention, accounted for a modest amount of the main intervention effect (22.0%).

## 5. Discussion

We found that web-based pharmacist case management improved blood pressure control in part through home blood pressure monitoring, electronic communication with providers and associated medication intensification. The entire effect was accounted for through communications outside the office with the vast majority from secure messaging, suggesting the intervention was successfully implemented and supported effective ongoing collaboration between patients and pharmacists. Contrary to our hypothesis, our measure of medication adherence did not change with the intervention and therefore did not mediate the intervention effect. Medication adherence, though, was high at baseline in both groups with 90–96% of individuals having 80% or more days with prescribed antihypertensive medications on hand. Another recent randomized trial of electronic communication and pharmacist outreach by Magid and colleagues had similarly high adherence (as measured by automated pharmacy data) among participants at baseline and found no change in adherence in the intervention versus control group during the study [25]. Although estimates of antihypertensive adherence vary based on method and population studied, adherence in both the Magid and the current study was substantially higher than expected given prior estimated rates of antihypertensive medication discontinuation at 50% per year and 10% of individuals omitting a medication on any given day [3]. A third recent trial of home blood pressure tele-monitoring and pharmacist care by Margolis and colleagues found higher self-reported adherence in the intervention versus control groups [26], suggesting the possibility that automated measures of adherence used in the Magid and the current study may also have been too coarse to find a difference between study groups. Lifestyle change also did not significantly mediate the intervention's effect on blood pressure control. Medication intensification explained only about a third of the intervention's effect on blood pressure, suggesting the possibility of unstudied mediators or the need for a more refined intensification measure to detect the full effect of medication changes on blood pressure outcomes.

To our knowledge, this is the first mediator analysis of a secure messaging based intervention targeting improvements in blood pressure control. Prior studies of home monitoring and case management in patients with hypertension, however, support our findings. A 2009 meta-analysis highlighted the value of home monitoring coupled with medication intensification for improving blood pressure control. A more recent trial in complex patients with diabetes also showed the importance of combining care management with home blood pressure monitoring and medication intensification to improve blood pressure control [1]. Finally, two other recent trials of home blood pressure monitoring and electronic communication with pharmacists found better blood pressure control and more antihypertensive medication intensification in the intervention versus control groups [25, 26]. These findings, in combination with our mediation analyses, highlight the importance of medication intensification by care managers in interventions using home blood pressure monitoring to improve hypertension control.

The strong effect of secure messaging in our results supports the important role of communication between patients and pharmacists for improving hypertension control. At least one other trial using home blood pressure monitoring combined with pharmacists outreach through secure messaging has found improved control of high blood pressure [25]. Trials combining secure messaging and case management for other conditions, including diabetes [27] and depression [28], have also found positive outcomes. Although no mediation or fidelity analyses were undertaken for these other studies, the intervention groups had higher amounts of secure messaging compared to the control groups. Similar models of care proactively using secure messaging for outreach may also be effective in other chronic conditions, particularly those that involve self-monitoring and medication adjustment.

Study limitations include an insured population with medication coverage, health care resources not available at most health plans, and lack of attention control. We also only enrolled patients who had internet access and an e-mail address. Measures of adherence and intensification based on pharmacy prescription and fill data may not have sufficiently captured patient medication-taking behavior. Providers may have increased or decreased anti-hypertensive doses at patient visits without changing the medication order in the EMR. Patients with medications in their possession may not have taken them. Other than fruit and vegetable intake, we did not assess dietary behaviors changes that may have impacted blood pressure. Patterns of electronic communication between patients and providers have evolved since the study was conducted. The relevance of our findings, however, is likely to increase as secure electronic messaging spreads through adoption of meaningful use criteria and as patients increasingly use mobile devices for electronic communication with providers. Finally, we did not test the validity, reliability or responsiveness of the self-report item for home blood pressure monitoring. Recall of home blood pressure monitoring over prior 12 months may also not be accurate. Future studies of mediation should seek stronger measures of adherence, intensification and lifestyle factors.

## 6. Conclusion

This study clarifies the role of electronic communication between office visits in supporting positive changes in medication intensification for hypertension control. Several healthcare systems have recently begun to address the known barriers to wider dissemination of secure electronic communication between patients and providers and direct patient access to portions of the EMR. These systems are using secure patient websites to provide a secure and confidential environment for communications [8, 29-33]. Combining home blood pressure monitoring and secure electronic messaging with pharmacist care management for medication intensification appears to be effective at improving blood pressure control among patients with essential hypertension.

### **Clinical Relevance Statement**

Web based pharmacist care can improve blood pressure control in patients with essential hypertension through the combined use of home blood pressure monitoring, secure electronic messaging and medication intensification.

### **Conflict of Interest**

The authors declare that they have no conflicts of interest in the research.

### **Human Subject Protection**

This study was reviewed and approved by the Group Health Research Institute's Institutional Review Board.

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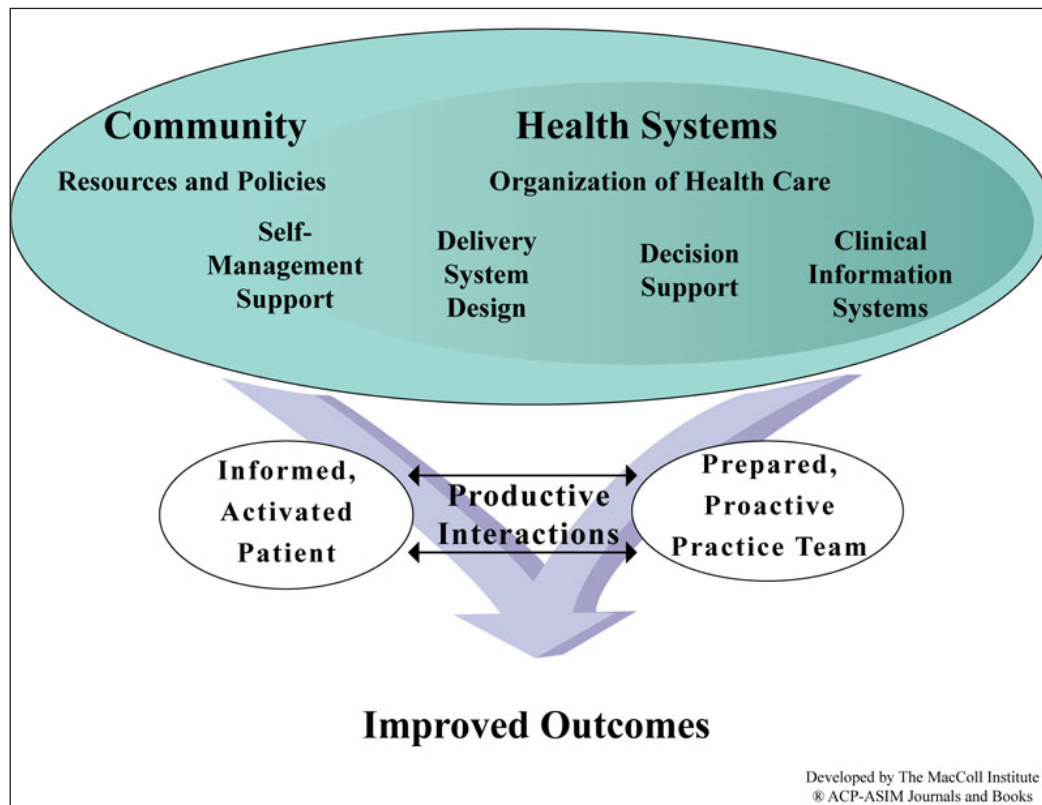


Fig. 1 The Chronic Care Model

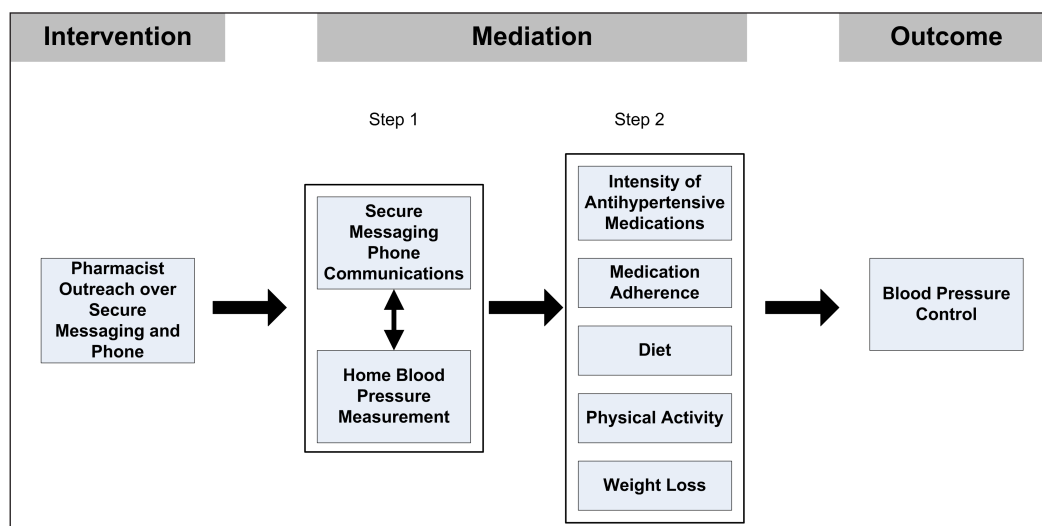


Fig. 2 Causal Model of eBP Intervention

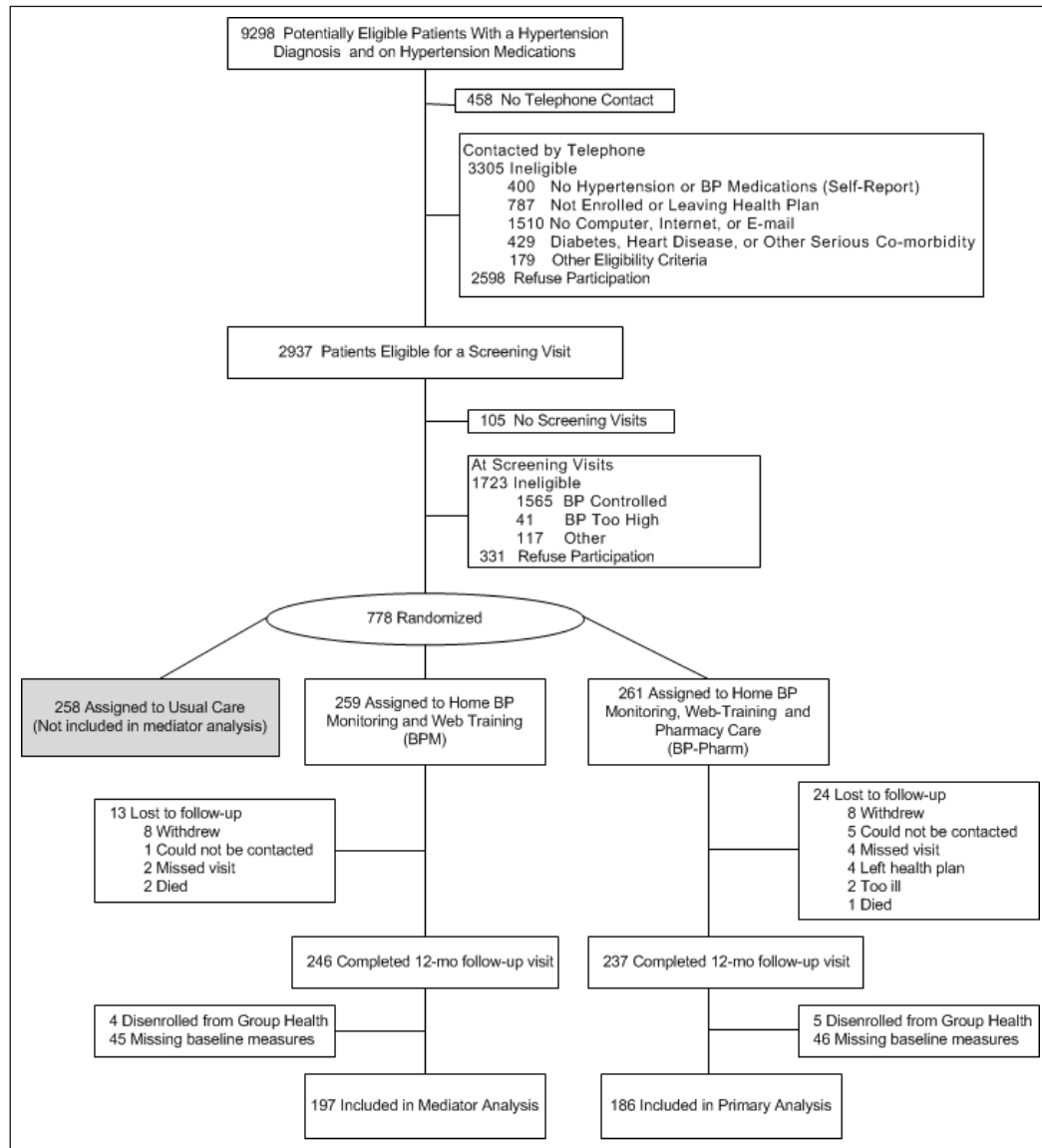


Fig. 3 Flow of Study Participants Through Recruitment, Intervention, and Blinded Follow-up Assessments

**Table 1** Baseline Characteristics of Hypertensive Patients by randomization group

	BPM		BPM-Pharm		Difference between Arms <i>P</i>
<b>N</b>	<b>197</b>		<b>186</b>		
<b>Demographics</b>					
Age, mean (sd)	59.8	(8.3)	59.8	(8.6)	0.971
Female, N (%)	109	(55.3)	82	(44.1)	0.028
<b>Race, N (%)</b>					
Caucasian	172	(87.3)	155	(83.3)	0.234
African American	12	(6.1)	9	(4.8)	
Asian	7	(3.6)	8	(4.3)	
Other/Refused to say	6	(3.0)	14	(7.5)	
<b>BMI, N (%)</b>					
Normal (18.5–24.9)	11	(5.6)	18	(9.7)	0.292
Overweight ( 25–29.9 )	67	(34.0)	57	(30.6)	
Obese (≥30)	119	(60.4)	111	(59.7)	
<b>Education, N (%)</b>					
≤12 years or GED	16	(8.1)	14	(7.5)	0.311
Some Post Highschool	84	(42.6)	63	(33.9)	
4 year College degree	55	(27.9)	60	(32.3)	
Post 4 year College degree	42	(21.3)	49	(26.3)	
<b>Employment, N (%)</b>					
Full-Time	92	(46.7)	99	(53.2)	0.445
Retired	84	(42.6)	73	(39.2)	
Part-Time	16	(8.1)	9	(4.8)	
Other/Refused to say	5	(2.5)	5	(2.7)	
<b>Potential Mediators</b>					
<b>Step 1</b>					
Have home BP machine, N (%)**	129	(65.5)	108	(58.1)	0.135
Hypertension Care in the last six months, N (%)**	169	(85.8)	153	(82.3)	0.346
Total Secure Message and Phone Encounters, mean (sd)	4.59	(6.5)	4.77	(5.5)	0.765
Phone Encounters, mean (sd)	2.82	(3.0)	3.22	(4.0)	0.260
<b>Step 2</b>					
Medication Adherence, N (%)	188	(95.4)	168	(90.3)	0.051
Number of Medication Classes, mean (sd)	1.38	(0.6)	1.42	(0.6)	0.550
Weight, mean (sd)	209	(52.5)	205	(46.5)	0.456
Godin Exercise, mean (sd)	30.8	(23.6)	26.1	(19.8)	0.037
Fruit and Vegatable servings, mean (sd)	3.57	(1.8)	3.55	(2.0)	0.917
PACIC, Overall, mean (sd)	2.12	(0.8)	2.25	(0.9)	0.180

Table 1 Continued

	BPM		BPM-Pharm		Difference between Arms <i>P</i>
<b>Blood Pressure</b>					
Systolic BP, mean (sd), mmHg	152.5	(10.4)	152.5	(10.1)	0.978
Diastolic BP, mean (sd), mmHg	88.6	(8.1)	88.2	(7.9)	0.629

\*Bold indicates significance at the 0.10 level

\*\*Since baseline measure of amount of home blood pressure monitoring was not available, presence of home BP machine is reported.

**Table 2** Potential Mediators, PACIC and In-Person Encounters by Treatment group over 12 month Intervention

	BPM n = 197		BPM-Pharm n = 186		P-value
Blood Pressure <140/90 mmHg, n (%)	72	(37)	102	(55)	0.001
<b>Step 1</b>					
Home blood pressure meter use, n (%)					
• Monthly or less	49	(24.9)	11	(5.9)	<0.001
• 2–4 times per month	73	(37.1)	20	(10.8)	
• 2 times per week	44	(22.3)	77	(41.4)	
• 3 or more times per week	31	(15.7)	78	(41.9)	
Secure messaging, mean (sd)	2.9	(4.3)	25.4	(9.5)	<0.001
• Patient-initiated	2.3	(3.9)	5.0	(6.6)	<0.001
• Provider-initiated	0.6	(0.9)	20.4	(6.5)	<0.001
Phone encounters, mean (sd)	3.1	(3.7)	5.3	(5.7)	<0.001
<b>Step 2</b>					
Medication intensification events total mean (sd)	0.6	(1.0)	1.1	(1.1)	<0.001
• Medication class intensification events	0.3	(0.6)	0.5	(0.7)	0.002
• Medication dose intensification events	0.1	(0.3)	0.2	(0.4)	0.001
• Medication class changes	0.2	(0.4)	0.4	(0.5)	0.001
Medication adherence (≥80%), n (%)	179	(90.9)	176	(94.6)	0.224
Weight change from baseline, mean (sd)	-0.9	(10.9)	-1.3	(10.8)	0.686
Godin exercise change from baseline, mean (sd)	-1.5	(24.0)	3.3	(22.1)	0.044
Fruit and vegetable intake, change from baseline, mean (sd)	0.2	(1.4)	0.3	(1.6)	0.650
PACIC, Overall, mean (sd)	2.5	(0.9)	3.3	(0.8)	<0.001
• Patient Activation	2.8	(1.2)	3.8	(1.1)	<0.001
• Delivery System Design	3.2	(1.1)	4.0	(0.9)	<0.001
• Goal Setting	2.5	(1.0)	3.5	(0.9)	<0.001
• Problem Solving	2.6	(1.2)	3.5	(1.1)	<0.001
• Follow-up and Coordination	1.6	(0.8)	2.1	(0.9)	<0.001
<b>In-Person Ambulatory Encounters, mean (sd)</b>					
Primary Care	3.0	(2.7)	3.1	(2.3)	0.734
Specialty Care	2.1	(2.7)	1.9	(2.6)	0.379
Emergency Care	0.1	(0.6)	0.2	(0.7)	0.912

(1) Tests for univariate difference in treatment group by Change process Variable using a chi-squared Score Test



**Table 3** Mediator and PACIC† Evaluation for Control of Blood Pressure (<140/90 mm Hg)

	BPM-Pharm vs BPM		
	RR	95% CI	% Reduction**
Adjusted RR of BP < 140/90 mm Hg, No Mediators*	1.50	1.20, 1.89	
<b>Step 1, Mediators</b>			
Home blood pressure measurement	1.33	1.02, 1.73	30.3
Combined phone and SM encounters	0.98	0.67, 1.44	100.0
• Phone Encounters	1.44	1.13, 1.82	11.4
• Secure Messaging	1.02	0.69, 1.50	96.0
<b>Step 2 Mediators</b>			
Combined Medication Intensification and Adherence	1.33	1.05, 1.68	29.9
• Medication Intensification	1.33	1.06, 1.68	29.3
• Medication Adherence	1.49	1.18, 1.87	2.6
Fruit and Vegetable Intake	1.51	1.20, 1.89	-0.3
Godin Change	1.52	1.21, 1.90	-1.8
Weight Change	1.49	1.19, 1.87	1.9
<b>PACIC†, overall score</b>	<b>1.37</b>	<b>1.07, 1.77</b>	<b>22.0</b>

\*All analyses adjust for sex, baseline systolic, baseline BMI, baseline Godin, baseline adherence, and primary clinic

\*\*% Reduction =  $100 * (\log(\text{RR}_{\text{nomediator}}) - \log(\text{RR}_{\text{mediator}})) / \log(\text{RR}_{\text{nomediator}})$

†PACIC: Patient Assessment of Chronic Illness Care

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