

A Pharmacist-Led, American Heart Association Heart360 Web-Enabled Home Blood Pressure Monitoring Program

David J. Magid, MD, MPH; Kari L. Olson, BSc(Pharm), PharmD; Sarah J. Billups, PharmD; Nicole M. Wagner, MPH; Ella E. Lyons, MS; Beverly A. Kroner, PharmD

Background—To determine whether a pharmacist-led, Heart360-enabled, home blood pressure monitoring (HBPM) intervention improves blood pressure (BP) control compared with usual care (UC).

Methods and Results—This randomized, controlled trial was conducted in 10 Kaiser Permanente Colorado clinics. Overall, 348 patients with BP above recommended levels were randomized to the HBPM (n=175) or UC (n=173) groups. There were no statistically significant differences in baseline characteristics between the groups; however, there was a trend toward a higher baseline BP for the HBPM group compared with the UC group (148.8 versus 145.5 mmHg for systolic BP; 89.6 versus 88.0 mmHg for diastolic BP). At 6 months, the proportion of patients achieving BP goal was significantly higher in the HBPM group (54.1%) than in the UC group (35.4%; $P<0.001$). Compared with the UC group, the HBPM group experienced a -12.4 -mmHg larger (95% confidence interval, -16.3 to -8.6) reduction in systolic BP and a -5.7 -mmHg larger (95% confidence interval, -7.8 to -3.6) reduction in diastolic BP. The impact of the intervention on BP reduction was even larger for the subgroup of patients with diabetes mellitus or chronic kidney disease. The HBPM group had more e-mail and telephone contacts and greater medication regimen intensification. The proportion of patients reporting high satisfaction with hypertension care was significantly greater in the HBPM group (58%) than in the UC group (42%), $P<0.001$.

Conclusions—A pharmacist-led, Heart360-supported, home BP monitoring intervention led to greater BP reductions, superior BP control, and higher patient satisfaction than UC.

Clinical Trial Registration—URL: <http://www.clinicaltrials.gov/ct2/show/NCT01162759>. Unique identifier: NCT01162759.

(*Circ Cardiovasc Qual Outcomes*. 2013;6:157-163.)

Key Words: blood pressure ■ home blood pressure monitoring ■ hypertension ■ randomized controlled trials ■ treatment effectiveness

Despite well-established evidence-based medication and behavioral therapies to treat hypertension, major gaps in blood pressure (BP) control remain.¹⁻³ Of the 76 million US adults with hypertension, more than half have uncontrolled BP.¹ Uncontrolled hypertension is associated with an increased risk of acute myocardial infarction, stroke, kidney failure, and congestive heart failure.¹ Lowering BP to recommended levels has been shown to reduce the occurrence of these events.⁴

To improve BP treatment and control rates, home BP monitoring (HBPM) has been suggested as an adjunct to traditional outpatient hypertension care.⁵⁻¹² Previous studies involving pharmacist- or nurse-led HBPM programs have demonstrated improvements in BP control.^{6,8,13,14} However, the applicability of these interventions to routine practice may be limited by reliance on complex HBPM protocols, a requirement for patients to make prescribed office visits in addition to HBPM, the exclusion of high-risk patients such as those with diabetes mellitus (DM) or chronic kidney disease (CKD), or the use of expensive, proprietary software to support telemonitoring.¹⁵

Additionally, previous studies required healthcare providers to reach out to patients at regular intervals, to manually obtain the home BP readings of the patients, and to manually calculate the averages before determining which patients required further intervention. For HBPM and interventions to be successful at a population level, innovative methods to streamline data into user-friendly reports that allow providers to focus care delivery will be important.

The objective of this pragmatic, randomized, controlled trial was to evaluate the effectiveness of a pharmacist-led, American Heart Association Heart360 Web-enabled HBPM intervention compared with usual care (UC) for patients with uncontrolled hypertension. The HBPM intervention, which was delivered by regular clinical staff, used a simple HBPM protocol, did not require patients to make office visits, included high-risk patients with DM and CKD, and used Heart360 (www.heart360.org), a widely available and free Web-enabled software for HBPM. We hypothesized that patients randomized to the HBPM group would achieve greater BP control than patients randomized to UC.

Received July 23, 2012; accepted December 31, 2012.

From Kaiser Permanente Colorado, Denver (D.J.M., K.L.O., S.J.B., N.M.W., E.E.L., B.A.K.); University of Colorado–Denver, Denver (D.J.M.); and University of Colorado Skaggs School of Pharmacy and Pharmaceutical Sciences, Aurora (K.L.O., S.J.B., B.A.K.).

The online-only Data Supplement is available at <http://circoutcomes.ahajournals.org/lookup/suppl/doi:10.1161/CIRCOUTCOMES.112.968172/-DC1>.

Correspondence to David Magid, MD, MPH, 10065 E Harvard Ave, Ste 300, Denver, CO 80231. E-mail david.j.magid@kp.org

© 2013 American Heart Association, Inc.

Circ Cardiovasc Qual Outcomes is available at <http://circoutcomes.ahajournals.org>

DOI: 10.1161/CIRCOUTCOMES.112.968172

WHAT IS KNOWN

- Previous studies involving pharmacist- or nurse-led home blood pressure (BP) monitoring programs have demonstrated improvements in BP control.
- However, the applicability of previous studies to routine practice may be limited by the exclusion of patients with diabetes mellitus or chronic kidney disease, complex monitoring protocols, or the use of expensive, proprietary software to support telemonitoring.

WHAT THE STUDY ADDS

- This pragmatic, randomized, controlled trial found that a pharmacist-led, Heart360-supported, home BP monitoring intervention delivered by regular clinical staff to a broadly representative patient population led to greater BP reductions, superior BP control, and higher patient satisfaction than usual care.
- The impact of the intervention on BP control and degree of BP lowering was even greater among the subset of patients with diabetes mellitus or chronic kidney disease.
- The proportions of patients with a dose increase for an antihypertensive medication or the addition of at least 1 antihypertensive medication were greater for the home BP monitoring group than for the usual care group.

Methods

Study Design and Setting

This was a pragmatic, randomized, controlled trial comparing HBPM intervention with UC for patients with diagnosed hypertension whose BP was higher than recommended levels. The American Heart Association Heart360 Web application (www.heart360.org) was used by patients in the HBPM group to transmit their home BP measurements to study staff. Heart360 is a free Web application for managing cardiovascular risk. With Heart360, patients can enter and store their BP readings (and other cardiovascular risk factor data), track progress toward attaining risk factor control, and receive educational information on cardiovascular risk. Heart360.org enables users to automatically upload data stored on home BP machines that have a USB port.

The study was conducted at Kaiser Permanente Colorado (KPCO), a group-model, closed-panel, nonprofit managed care organization that cares for >500 000 members in the Denver-Boulder metropolitan area. Outpatient medical services are provided at 18 primary care clinics spread geographically across the metropolitan area. This study was conducted at 10 of these primary care clinics. Each clinic is staffed with ≥ 1 clinical pharmacy specialists who assist primary care providers with drug therapy management. With regard to hypertension management, clinical pharmacy specialists work under preapproved collaborative drug therapy management protocols that permit them to initiate or change antihypertensive medications, to adjust medication doses, and to order laboratory tests related to medication monitoring. KPCO clinicians use a commercially available EpicCare electronic health record (EHR) as part of routine care delivery. The KPCO EHR has a feature called My Chart that allows patients and their providers to communicate through a password-protected Web site. The study was approved by the KPCO Institutional Review Board.

Patient Population

Adults 18 to 79 years of age were eligible if they (1) had a diagnosis of hypertension and their 2 most recent clinic BP readings were above goal (systolic BP [SBP] ≥ 140 mmHg or diastolic BP [DBP] ≥ 90 mmHg or,

for those with DM or CKD, SBP ≥ 130 mmHg or DBP ≥ 80 mmHg); (2) were prescribed ≤ 3 antihypertensive medications; (3) had a primary care provider who worked at 1 of the 10 participating clinics; and (4) were registered on the KPCO My Chart Web site (which suggested that they had access to a computer and the Internet).

Patients were excluded if they (1) had a limited life expectancy (eg, patients in hospice or palliative care); (2) were ≥ 80 years of age because aggressive BP reduction may not be appropriate for these patients; (3) had a recent myocardial infarction, stroke, percutaneous coronary intervention, or coronary artery bypass graft surgery because KPCO patients receive enhanced hypertension care as part of intensive cardiac rehabilitation in the year after the event; (4) had end-stage renal disease because hypertension care for these patients is provided by nephrology specialists instead of primary care providers; or (5) did not speak English. Patients were also excluded if they did not have access to the Internet and a computer with a USB port and Internet Explorer 6.0 or higher, if their BP measured at the baseline enrollment visit (described below) was already at goal, or if the home BP cuff could not be validated (eg, the home BP reading was not within 5 mmHg of the baseline BP).

Recruitment and Enrollment

Potentially eligible patients were identified by screening BP measurements and other clinical data recorded in the EHR. Patients were mailed an invitation letter containing a description of the study along with an opt-out postcard. Patients who did not return the opt-out postcard were contacted by telephone by research staff to describe the study and to determine eligibility. Patients who expressed interest in participating in the study were invited to a baseline clinic visit.

Eligible patients were randomly allocated to the HBPM or UC groups. A random allocation sequence was computer generated using stratified randomization with an allocation ratio of 1:1. We used commercially available statistical software (SAS RANUNI function; SAS Institute Inc, Cary, NC) to generate the assignment list for each stratum. The sequence was concealed from the patient until the baseline visit.

Baseline study visits were conducted between October 2008 and December 2009. At these visits, patients provided written informed consent and had their BP taken by a clinic nurse using a standardized protocol.¹⁶ After the patient sat for at least 5 minutes, the nurse took the BP of the patient 3 times 2 minutes apart using an electronic BP cuff (VSM MedTech BPM-100 Professional Blood Pressure Monitor: A/A grade from the British Hypertension Society). Patients whose mean BP was above their goal were eligible for study participation.

UC and HBPM Intervention

Patients assigned to the UC group were advised that their BP was elevated; received written educational materials on managing high BP, diet, and physical activity; and were instructed to follow up with their primary care physician. In addition, the patient's physician was notified of the patient's elevated BP via a note sent to the EHR in-box of the physicians.

In addition to receiving the same educational materials as the UC group, patients assigned to the HBPM intervention group were provided a properly fitted home BP cuff (Omron HEM-790IT) and were trained on how to use it. Patients were assisted in establishing an account at the Heart360 Web site and were shown how to automatically upload BPs stored on their home BP device into their Heart360 account. Patients in the HBPM group also met with a clinical pharmacy specialist who reviewed their current BP medication regimen, provided counseling on lifestyle changes, and adjusted or changed antihypertensive medications as needed.

Patients were asked to measure their BP at least 3 times per week and to upload their BPs to their Heart360 account weekly. From the Heart360 account, BPs were automatically uploaded nightly to KPCO and organized into BP summary reports that were viewed by the clinical pharmacy specialists managing their care. The reports summarized weekly BP averages and flagged patients with averages above their goal. The clinical pharmacy specialist reviewed the home BP measurements and adherence to antihypertensive medications of the

patients, made medication adjustments as needed, and communicated with patients via telephone or secure e-mail. Any medication changes were communicated to the primary care physician of the patient through the EHR. Patients who neglected to upload their BP readings as instructed received up to 3 reminder phone calls through an automated interactive voice response system. If a patient still failed to upload readings, he or she received a call from a clinic staff member.

Six-Month Visit

Patients in both groups returned for a clinic visit at 6 months, at which time they had their BP taken by a research assistant blinded to study group assignment using the same standardized protocol that was used at the baseline visit. In addition, all patients were asked to rate their overall satisfaction with their hypertension care and the degree to which they were engaged in their hypertension care during the 6-month study period. Patients in the HBPM group were also asked about how easy it was to measure their BP at home and how easy it was to upload their BPs to Heart360 and to rate their interactions with the clinical pharmacy specialist.

Outcome Measures

The primary outcome was the proportion of patients who attained their goal BP at the 6-month clinic visit. BP goals were <140/90 mmHg for all patients except those with DM and CKD, whose goal was <130/80 mmHg.¹⁶ Secondary outcomes included change in SBP and DBP between the baseline and 6-month clinic visits, change in antihypertensive medication intensity, and antihypertensive medication adherence. Medication intensity was measured by comparing the proportion of patients in each group with at least 1 antihypertensive medication added between the baseline and the 6-month visit and the proportion with at least 1 dose increase for an antihypertensive medication that they were taking at baseline. Medical service used, including all hospitalizations, emergency department visits, clinic visits, telephone encounters, and e-mail encounters, was assessed via chart review. Patients in the HBPM group were asked to measure their home BP at least 3 times per week and to upload readings weekly. Patients were considered to be adherent to the BP monitoring protocol if they measured and uploaded home BP readings for $\geq 80\%$ of the weeks during the study intervention. The mean and median number of BP measurements per upload were also recorded.

For patients who purchased their medications from a KPCO pharmacy, medication adherence was calculated from a medication possession ratio based on the total number of days supplied for each filled antihypertensive medication, less the supply that would extend beyond the end of the 6-month study period, divided by the period for which the medication was prescribed. For patients on multiple antihypertensive medications during this time, adherence to each medication was averaged to derive a summary adherence measure.

Sample Size

This study was designed to enroll up to 200 patients per group allocated equally to the HBPM and UC groups. Assuming a 15% dropout rate and a control rate of 30% in the UC group, this sample size provided 80% power to detect a 14% difference in BP control rate in the HBPM group compared with the UC group.

Statistical Analysis

All statistical analyses were performed on an intention-to-treat basis with SAS version 9.1 software (SAS, Cary, NC). In the primary analyses, all patients randomized at baseline were included. Baseline characteristics were reported as means, medians, and SDs for interval- and ratio-level variables (eg, age) and proportions for nominal- and ordinal-level data (eg, sex, comorbidities). Interval-level outcome variables were assessed for normality of their distributions, and appropriate tests were used to assess differences in mean values between groups (eg, *t* test, rank-sum test). To assess differences in proportions between groups on categorical variables, the Pearson χ^2 test of association was used.

There were 22 people who did not complete the 6-month follow-up visit and were missing BP outcomes for this study. Two methods were used to include all people randomized at baseline in these analyses. For analyses of BP change, we estimated generalized linear models with a separate record for each time period: baseline and 6-month follow-up. Individuals missing outcome data at 6 months ($n=22$) have only a baseline record in this model, whereas all others contributed 2 records. The intervention effect was estimated via an interaction with time, assuming an unstructured covariance matrix and clustering within clinic estimated as a random effect. To help account for potential differences in individuals missing 6-month follow-up data, the models included covariates for age, sex, race, number of medications,

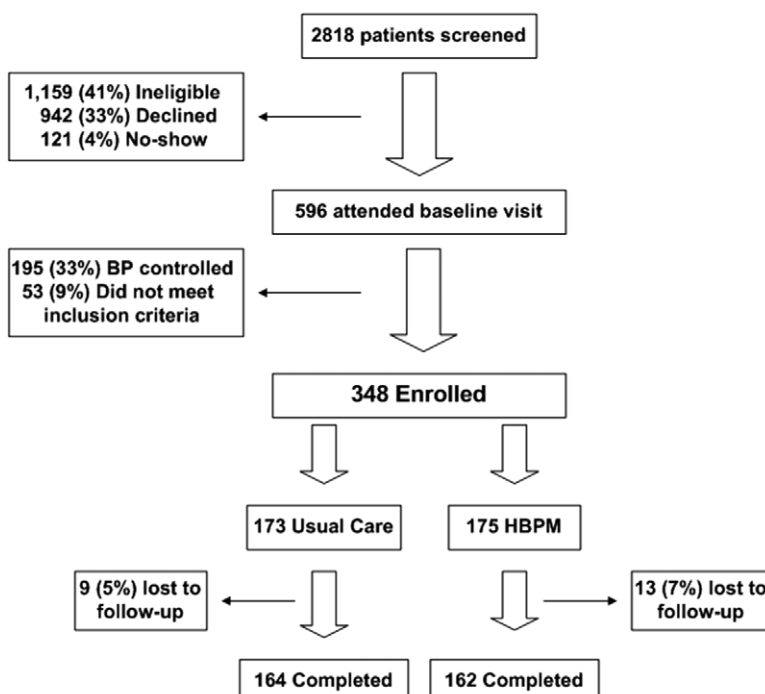


Figure 1. Patient flow diagram. BP indicates blood pressure; and HBPM, home blood pressure monitoring.

and in the full cohort model, an indicator for DM/CKD. For analyses of BP control, similar models could not be estimated because at baseline all study subjects were not in control. We instead used multiple imputations to estimate BP control for the 22 people missing this outcome. Imputation models included the covariates listed above and variables for baseline SBP and DBP. Missing data were monotonic, and we used the logistic option of Proc MI (SAS 9.2) to produce 10 imputations. BP control was analyzed through the use of binomial models and generalized estimating equation methods to account for repeated subjects per clinic. We completed models for each imputed data set and combined results with Proc MIanalyze. Adjusted BP control outcome models controlled for age, sex, race, baseline BP, and in the full cohort model, an indicator for DM/CKD. Missing data were

relatively low in this study (6.3%), and the results were comparable in complete case analyses.

Results

Figure 1 shows the flow of patients through the initial screening, baseline visit, randomization, and 6-month follow-up phases of the study. Of 348 patients enrolled in the study, 326 (94%) completed the 6-month visit (162 in the HBPM group; 164 in the UC group). The median time to follow-up was 182 days for both groups. There were no significant differences in the demographic and clinical characteristics of those who completed the 6-month visit and those who did not.

The study population had a mean age of 60 years; 40% were female and 83% were white. Nearly half of these patients (49%) had DM and CKD. There were no statistically significant differences in baseline demographic and clinical characteristics of the HBPM and the UC patients (Table 1). However, there was a trend toward a higher mean baseline BP for the HBPM group compared with the UC group (148.8 versus 145.5 mm Hg for SBP; 89.6 versus 88.0 mm Hg for DBP).

After 6 months, the mean BPs were significantly lower in the HBPM group than in the UC group (128.1 versus 137.4 mmHg, $P<0.001$ for SBP; 79.1 versus 83.1 mmHg, $P<0.01$ for DBP). The proportion of patients achieving BP goal at 6 months was significantly higher in the HBPM group (54.1%) than in the UC group (35.4% adjusted risk ratio, 1.5; 95% confidence interval [CI], 1.2–1.9; Figure 2). In the subset of patients with DM and CKD, the proportion of patients achieving BP goal was also higher in the HBPM group (51.7% versus 21.9%; adjusted risk ratio, 2.5; 95% CI, 1.6–3.8; Figure 2).

Average SBP and DBP decreased significantly in both groups over the study period (Figure 3). Compared with the UC group, the HBPM group experienced a 12.4-mmHg larger drop in SBP (95% CI, –16.3 to –8.6) and a 5.7-mmHg larger drop in DBP (95% CI, –7.8 to –3.6). The impact of the intervention on BP lowering was even greater in the subset of patients with DM and CKD. Within this cohort, the HBPM group experienced a 15.4-mmHg larger drop in SBP (95% CI, –21.0 to –9.8) and a 7.3-mmHg larger drop in DBP (95% CI, –10.4 to –4.1).

Of the 326 patients who completed the 6-month visit, more HBPM patients had an antihypertensive medication added to their regimen than UC patients (113 [70%] versus 41 [25%]; $P<0.001$; Table 2). Similarly, a greater number of HBPM patients had the dose increased for an existing antihypertensive medication (69 [43%] versus 20 [12%] in the UC group; $P<0.001$). Overall, 120 of the 147 HBPM patients (82%) using prescription antihypertensive medications and 115 of the 158 UC patients (73%) purchased their antihypertensive medications exclusively at KPCO pharmacies during the study period. Among this group, there was no difference in the mean medication possession ratio adherence score over the 6-month study period (0.86 versus 0.87; $P=0.93$).

The proportion of patients at 6 months reporting that they were very or completely satisfied with their hypertension care was significantly higher in the HBPM group (58%) than in the UC group (42%; $P<0.001$). More patients in

Table 1. Baseline Characteristics of the Study Population

Characteristics	Usual Care (n=173)	Home Blood Pressure Monitoring (n=175)
Mean age (SD), y	59.1 (10.9)	60.0 (11.3)
Male, n (%)	102 (59.0)	108 (61.7)
Race, n (%)		
White	146 (84.4)	143 (81.7)
Black	14 (8.1)	15 (8.6)
Asian	1 (0.6)	5 (2.9)
Other	12 (6.9)	12 (6.9)
Ethnicity, n (%)		
Hispanic	10 (5.8)	16 (9.1)
Current smoking, n (%)	13 (7.5)	17 (9.7)
Diabetes mellitus or chronic kidney disease, n (%)	88 (50.9)	81 (46.3)
Systolic blood pressure, mean (SD), mm Hg	145.5 (14.5)	148.8 (16.2)
Diastolic blood pressure, mean (SD), mm Hg	88.0 (9.9)	89.6 (10.2)
No medication, n (%)	19 (11.0)	24 (13.7)
Thiazide diuretic, n (%)	70 (40.5)	81 (46.3)
ACE inhibitor/ARB, n (%)	109 (63.0)	104 (59.4)
β -Blocker, n (%)	53 (30.6)	43 (24.6)
Calcium channel blocker, n (%)	33 (19.1)	32 (18.3)
Other, n (%)	17 (9.8)	15 (8.6)
Medications, mean (SD), n	1.6 (0.8)	1.6 (0.7)
Medication intensity score, mean (SD)	2.7 (1.9)	2.7 (1.8)
Clinic, n (%)		
1	9 (5.2)	12 (6.9)
2	11 (6.4)	9 (5.1)
3	29 (16.8)	27 (15.4)
4	27 (15.6)	24 (13.7)
5	21 (12.1)	23 (13.1)
6	1 (0.6)	12 (6.9)
7	20 (11.6)	19 (10.9)
8	21 (12.1)	19 (10.9)
9	24 (13.9)	16 (9.1)
10	10 (5.8)	14 (8.0)

ACE indicates angiotensin-converting enzyme; and ARB, angiotensin receptor blocker.

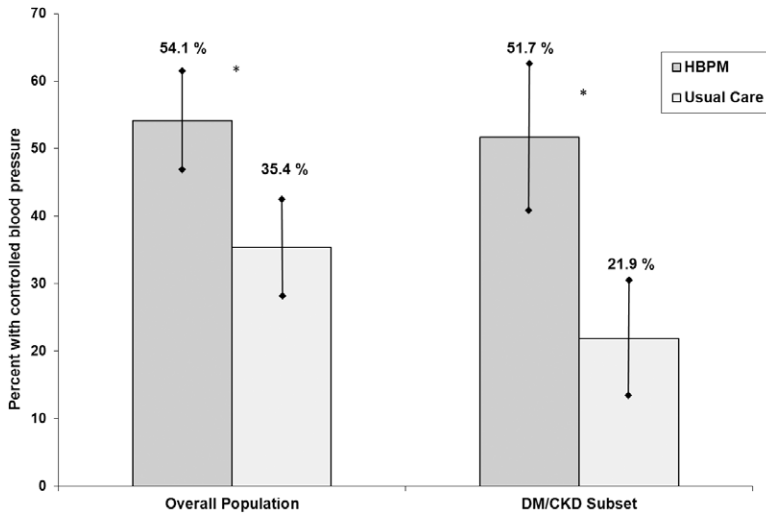


Figure 2. Six-month rates and 95% confidence intervals of blood pressure control for the home blood pressure monitoring (HBPM) intervention and the usual care groups. CKD indicates chronic kidney disease; and DM, diabetes mellitus.

the HBPM group also reported paying increased attention to their BP (60% versus 40% in the UC group; $P<0.001$). Finally, 68% of HBPM patients reported that the home BP cuff and Heart360 monitoring system were very or extremely easy to use, and the majority of patients (52%) found their interactions with the clinical pharmacy specialist to be very or extremely helpful.

With regard to health care used, the mean number of outpatient clinic visits was similar for the HBPM and UC groups (3.3 versus 3.1; $P=0.16$; Table 3). The total number of emergency department visits (6 for HBPM and 9 for UC, $P=0.44$) and hospitalizations (5 for HBPM and 7 for UC $P=0.57$) did not differ significantly between the 2 groups. However, compared with the UC group, the HBPM group had a higher mean number of e-mail encounters (6.0 versus 2.4; $P<0.001$) and telephone encounters (5.3 versus 3.5; $P=0.02$).

Overall, 113 of 162 HBPM patients (70%) were adherent to the BP monitoring protocol, uploading their home BP readings for 80% or more of the weeks during the study intervention. A total of 156 patients (96%) measured and uploaded home BP readings for half or more of the weeks during the

study intervention. The mean and median number of BP readings per upload were 7.3 (SD, 8.6) and 5 (25th–75th percentile, 3–9), respectively.

Discussion

This pragmatic clinical trial of a pharmacist-led, Heart360-supported HBPM intervention led to higher rates of BP control and greater BP reductions than UC. The impact of the intervention on BP control and degree of BP lowering was even greater among the subset of patients with DM and CKD. Although the intervention required patients to regularly monitor home BP readings, to upload the readings into the Heart360 Web site, and to have regular contact with a clinical pharmacy specialist, most patients found the intervention easy to use, and HBPM patients reported higher satisfaction with their hypertension care than those who received UC. Additionally, whereas there was no difference between groups in clinic, emergency department, or hospital visits, patients in the HBPM group had more e-mail and telephone encounters than patients in the UC group.

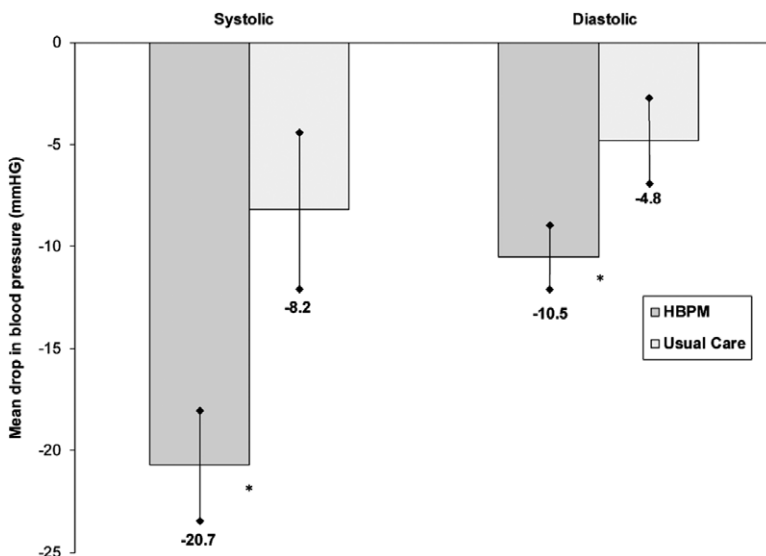


Figure 3. Reduction in systolic and diastolic blood pressures and 95% confidence intervals for the home blood pressure monitoring (HBPM) intervention and the usual care groups.

Table 2. Medication Used at 6 Months

Characteristics	Usual Care (n=164)	Home Blood Pressure Monitoring (n=162)	P
No medication, n (%)	15 (9.2)	6 (3.7)	0.05
Diuretic, n (%)	77 (47.0)	109 (67.3)	<0.001
ACE inhibitor/ARB, n (%)	109 (66.5)	123 (75.9)	0.06
β -Blocker, n (%)	55 (33.5)	54 (33.3)	0.97
Calcium channel blocker (%)	40 (24.4)	74 (45.7)	<0.001
Other, n (%)	11 (6.7)	16 (9.9)	0.30
Patients with ≥ 1 medications added, n (%)	41 (25)	113 (70)	<0.001
Patients with ≥ 1 medication dose increases, n (%)	20 (12)	69 (43)	<0.001
Change in medication intensity score from baseline to 6 mo, mean (SD)	0.15 (0.82)	1.35 (1.37)	<0.001

ACE indicates angiotensin-converting enzyme; and ARB, angiotensin receptor blocker.

This findings of the study are consistent with previous studies showing that pharmacist- or nurse-led HBPM interventions can lead to higher rates of BP control and greater BP reductions than UC.^{6,8,13,14} Our study goes beyond previous studies by demonstrating that improved BP control can be achieved with a relatively simple home monitoring protocol and without requiring patients to make additional office visits. Previous studies have often relied on the use of expensive, proprietary software to support monitoring of BP measurements. In contrast, our study used the freely available Heart360 Web application for BP monitoring. An additional advancement was the use of BP summary reports that provided pharmacists with data on individual BP measurements and the average of the home BP readings and categorized patients as either controlled or uncontrolled on the basis of their specific BP target goal. The reports streamlined care and improved efficiency because providers could focus their time on those patients with elevated home BP readings. Finally, the generalizability of the study results is enhanced by the use of a pragmatic study design in which the intervention was delivered by regular clinical staff to a broadly representative patient population with uncontrolled hypertension that included participants with DM and CKD, high-risk groups that have been excluded in previous HBPM studies.⁸

We believe the success of the HBPM intervention can be attributed to several factors. First, clinical pharmacy specialists are ideally suited to deliver the intervention because of their expertise in medication therapy management. Collaborative drug therapy management protocols allow them to make necessary dose adjustments, to add or discontinue

antihypertensive medications, and to order laboratory tests to monitor for adverse effects. Second, the Heart360 Web application provided intervention patients with a simple and efficient way to transmit BP measurements to their clinical pharmacy specialist while keeping patients engaged by providing them with feedback on their progress toward attaining BP control and easy-to-read educational information. Finally, the BP summary reports enabled clinical pharmacy specialists to focus medication intensification efforts on those individuals with elevated home BP readings, whereas the remaining patients could view graphic representations of their controlled BP readings through the Heart360 Web application and required contact with the healthcare team only if their home BP readings increased above goal.

It was not possible for UC patients to access the Heart360 Web application during the study period. However, because HBPM and UC subjects could be treated by the same primary care providers, it is possible that physicians caring for UC patients may have been more aggressive than usual in addressing elevated BP. However, we would expect that the impact of such contamination would be to bias the results toward the null, suggesting that, if anything, the benefits of the HBPM intervention maybe larger than what we have reported. Primary care physicians consulted pharmacists on the hypertension medication regimen for 22 of the UC patients (14%) because this type of interaction is part of UC at KPCO. A chart review of these consultations demonstrates that in each instance the pharmacist provided appropriate guideline-based care that was similar to the recommendations that were made for the patients in the HBPM group.

Table 3. Health Care Used

Characteristics	Usual Care (n=164), n (%)	Home Blood Pressure Monitoring (n=162), n (%)	P
Clinic visits	3.1 (2.3)	3.3 (2.5)	0.16
ED visits	0.05 (0.23)	0.04 (0.19)	0.44
Hospitalizations	0.04 (0.20)	0.03 (0.17)	0.57
Telephone encounters	3.5 (3.8)	5.3 (4.5)	0.02
E-mail encounters	2.4 (3.2)	6.0 (5.5)	<0.01

ED indicates emergency department. Values are mean (SD).

We acknowledge several limitations. The study was conducted in a single healthcare system with an EHR and clinical pharmacy specialists; therefore, the results may not be applicable to all settings. To participate in the intervention, patients had to have access to a computer and the Internet, which may not be available to all patients with hypertension. Because outcomes were assessed only at 6 months, the durability of the intervention effects beyond this time frame is unknown. Because patients ≥ 80 years of age were excluded, the generalizability of the findings to this age group is unknown. Finally, our ability to assess medication adherence was limited by the relatively short 6-month time frame and the challenge in using pharmacy refill data to assess adherence during periods when changes to the antihypertensive medication regimen were frequent.

Conclusion

A pharmacist-led, American Heart Association Heart360 Web-enabled home BP intervention led to higher rates of BP control and larger BP reductions than UC for patients with uncontrolled hypertension. Patients enrolled in the intervention also reported significantly greater satisfaction with their hypertension care than patients receiving UC. Future research should focus on translating the intervention to other settings and patient populations and to assessing the sustainability and cost-effectiveness.

Acknowledgments

We would like to thank Heather Nuanes and Susan Shetterly for their contributions to the conduct of this study. We would also like to thank the primary care clinical pharmacy specialists for their hard work, clinical expertise and support of this project.

Source of Funding

The study was funded in part by the American Heart Association. The content is solely the responsibility of the authors and does not necessarily represent the official views of the American Heart Association.

Disclosures

None.

References

1. Roger VL, Go AS, Lloyd-Jones DM, Benjamin EJ, Berry JD, Borden WB, Bravata DM, Dai S, Ford ES, Fox CS, Fullerton HJ, Gillespie C, Hailpern SM, Heit JA, Howard VJ, Kissela BM, Kittner SJ, Lackland DT, Lichtman JH, Lisabeth LD, Makuc DM, Marcus GM, Marelli A, Matchar DB, Moy CS, Mozaffarian D, Mussolino ME, Nichol G, Paynter NP, Soliman EZ, Sorlie PD, Sotodehnia N, Turan TN, Virani SS, Wong ND, Woo D, Turner MB; American Heart Association Statistics Committee and Stroke Statistics Subcommittee. Heart disease and stroke statistics—2012 update: a report from the American Heart Association. *Circulation*. 2012;125:e2–e220.
2. Ong KL, Cheung BM, Man YB, Lau CP, Lam KS. Prevalence, awareness, treatment, and control of hypertension among United States adults 1999–2004. *Hypertension*. 2007;49:69–75.
3. Redberg RF, Benjamin EJ, Bittner V, Braun LT, Goff DC Jr, Havas S, Labarthe DR, Limacher MC, Lloyd-Jones DM, Mora S, Pearson TA, Radford MJ, Smetana GW, Spertus JA, Swegler EW; American Academy of Family Physicians; American Association of Cardiovascular and Pulmonary Rehabilitation; Preventive Cardiovascular Nurses Association. ACCF/AHA 2009 performance measures for primary prevention of cardiovascular disease in adults: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Performance Measures (Writing Committee to Develop Performance Measures for Primary Prevention of Cardiovascular Disease) developed in collaboration with the American Academy of Family Physicians; American Association of Cardiovascular and Pulmonary Rehabilitation; and Preventive Cardiovascular Nurses Association; endorsed by the American College of Preventive Medicine, American College of Sports Medicine, and Society for Women's Health Research. *J Am Coll Cardiol*. 2009;54:1364–1405.
4. Law MR, Morris JK, Wald NJ. Use of blood pressure lowering drugs in the prevention of cardiovascular disease: meta-analysis of 147 randomised trials in the context of expectations from prospective epidemiological studies. *BMJ*. 2009;338:b1665.
5. Parati G, Omboni S, Albini F, Piantoni L, Giuliano A, Revera M, Illyes M, Mancina G; TeleBPCare Study Group. Home blood pressure telemonitoring improves hypertension control in general practice: the TeleBPCare study. *J Hypertens*. 2009;27:198–203.
6. Magid DJ, Ho PM, Olson KL, Brand DW, Welch LK, Snow KE, Lambert-Kerzner AC, Plomondon ME, Havranek EP. A multimodal blood pressure control intervention in 3 healthcare systems. *Am J Manag Care*. 2011;17:e96–e103.
7. Bosworth HB, Powers BJ, Olsen MK, McCant F, Grubber J, Smith V, Gentry PW, Rose C, Van Houtven C, Wang V, Goldstein MK, Oddone EZ. Home blood pressure management and improved blood pressure control: results from a randomized controlled trial. *Arch Intern Med*. 2011;171:1173–1180.
8. Green BB, Cook AJ, Ralston JD, Fishman PA, Catz SL, Carlson J, Carrell D, Tyll L, Larson EB, Thompson RS. Effectiveness of home blood pressure monitoring, Web communication, and pharmacist care on hypertension control: a randomized controlled trial. *JAMA*. 2008;299:2857–2867.
9. Agarwal R, Bills JE, Hecht TJ, Light RP. Role of home blood pressure monitoring in overcoming therapeutic inertia and improving hypertension control: a systematic review and meta-analysis. *Hypertension*. 2011;57:29–38.
10. Rinfret S, Lussier MT, Peirce A, Duhamel F, Cossette S, Lalonde L, Tremblay C, Guertin MC, LeLorier J, Turgeon J, Hamet P; LOYAL Study Investigators. The impact of a multidisciplinary information technology-supported program on blood pressure control in primary care. *Circ Cardiovasc Qual Outcomes*. 2009;2:170–177.
11. Godwin M, Lam M, Birtwhistle R, Delva D, Seguin R, Casson I, MacDonald S. A primary care pragmatic cluster randomized trial of the use of home blood pressure monitoring on blood pressure levels in hypertensive patients with above target blood pressure. *Fam Pract*. 2010;27:135–142.
12. Pickering TG, Miller NH, Oggedegbe G, Krakoff LR, Artinian NT, Goff D; American Heart Association; American Society of Hypertension; Preventive Cardiovascular Nurses Association. Call to action on use and reimbursement for home blood pressure monitoring: executive summary: a joint scientific statement from the American Heart Association, American Society of Hypertension, and Preventive Cardiovascular Nurses Association. *Hypertension*. 2008;52:1–9.
13. Mehos BM, Saseen JJ, MacLaughlin EJ. Effect of pharmacist intervention and initiation of home blood pressure monitoring in patients with uncontrolled hypertension. *Pharmacotherapy*. 2000;20:1384–1389.
14. Rudd P, Miller NH, Kaufman J, Kraemer HC, Bandura A, Greenwald G, Debusk RF. Nurse management for hypertension: a systems approach. *Am J Hypertens*. 2004;17:921–927.
15. Fahey T, Schroeder K, Ebrahim S. Interventions used to improve control of blood pressure in patients with hypertension. *Cochrane Database Syst Rev* 2006; CD005182.
16. Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL Jr, Jones DW, Materson BJ, Oparil S, Wright JT Jr, Roccella EJ; National Heart, Lung, and Blood Institute Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure; National High Blood Pressure Education Program Coordinating Committee. The seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 report. *JAMA*. 2003;289:2560–2572.