

Feasibility of a Self-Measured Blood Pressure Monitoring Program to Reduce Uncontrolled Hypertension

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ABSTRACT

BACKGROUND: Hypertension is a common, serious condition affecting about one-third of adults in the United States. Self-measured blood pressure (SMBP) monitoring, combined with clinical support, is recommended to improve hypertension control and patient outcomes.

METHODS: We conducted a retrospective analysis of a SMBP monitoring program that supported recruited patients in using wireless Bluetooth monitors to track their blood pressure at home and gave outpatient practices real-time access to patients' measurements. We analyzed SMBP measurements, practice-user log data, and patient and practice experience evaluations.

RESULTS: Project staff recruited 17 outpatient practices and 187 patients. After four weeks, 64% of participants consistently monitored their blood pressure at least three times per week. A majority of patients (79%) reported an increased ability to manage their hypertension. In total, clinicians received 1,849 alerts and documented 409 actions.

CONCLUSIONS: This analysis demonstrates the feasibility of combining SMBP with real-time access to home measurements by outpatient practices.

KEYWORDS: hypertension, blood pressure, self-monitoring, ambulatory medicine remote patient monitoring

INTRODUCTION

Hypertension is a common, serious condition that affects about a third of U.S. adults.¹ The risk of hypertension increases with age, for those with limited social and economic resources, and for those who are overweight or obese, and hypertension frequently coexists with other risk factors and chronic diseases.² Furthermore, racial disparities exist: Black Americans have greater risk for hypertension and poor outcomes related to hypertension compared to White Americans.³ About half of people with hypertension do not have their blood pressure under control,⁴ which increases cardiovascular morbidity and mortality.

Adherence to hypertension treatment, which includes healthy lifestyle adoption, pharmacotherapy, or a combination, is essential for blood pressure control,⁵ but barriers may

hinder patients from seeking treatment, adopting a healthier lifestyle, or taking their medication appropriately.⁶ For example, patients may face challenges accessing transportation to primary care practices, pharmacies, physical activity facilities, or grocery stores.⁷ Therefore, patient engagement, social support, and self-management strategies to improve adherence are critical.⁸

Self-measured blood pressure (SMBP) monitoring, combined with additional clinical support, has been recommended to improve adherence to medications and behavioral modifications, particularly for the elderly.⁹ Therefore, Healthcentric Advisors, a nonprofit healthcare quality improvement organization, implemented an SMBP monitoring program in Rhode Island. The program supported participants in using home blood pressure monitors to regularly track their blood pressures and to wirelessly provide real-time data to the participants' physicians. The objective of this study was to assess the feasibility of this SMBP monitoring program through an analysis of user-log data, as well as patient and practice evaluations. We hypothesized that implementing an SMBP monitoring program is feasible from the perspectives of both patients and physician practices.

METHODS

Participants and Setting

The SMBP intervention was intended to engage patients with uncontrolled hypertension in Rhode Island to measure and self-manage their blood pressure. Healthcentric Advisors partnered with 17 outpatient practices to identify and recruit eligible patients, with a focus on populations who are disproportionately impacted by hypertension. The program began in September 2019 and is ongoing. This study includes data from September 2019 through November 2020.

Intervention

Participating practices either recruited patients directly (assessing them for eligibility during a patient encounter using a screening tool) or referred patients to project staff to screen via telephone. Inclusion criteria included uncontrolled hypertension, defined as a blood pressure greater than 140/90 mm Hg, and access to a cell phone or tablet with wireless Internet and Bluetooth capability. Patients signed a participation agreement to acknowledge their commitment

and understanding that project staff would share their data with their primary care practice and would use de-identified results to evaluate the success of the program.

Participants were trained in SMBP techniques by a member of the practice or by project staff. Patients were provided with an Omron Series 10 wireless Bluetooth-enabled blood pressure monitor at no cost. Each time that patients measured their blood pressure with the monitor, the results were transmitted directly into their Omron account. The results were then added to Healthcentric Advisors' HIPAA-compliant database in real time through an Application Program Interface (API) created to connect patients' secure Omron accounts with the database.

Clinicians and other staff (e.g., nurse care managers, care coordinators, practice-based pharmacists) at participating practices were able to view their patients' results by logging into Healthcentric Advisors' secure portal. The portal displayed several reports for practices, including trends of weekly averages by patient, alert reports, and action reports.

Automated email notifications alerted practice staff about high priority or outlier patient results. By default, outlier readings were defined as: low (below 100/60 mm Hg), high (between 160/100 mm Hg and 180/110 mm Hg), and critical high (above 180/110 mm Hg). Clinicians could customize the parameters that defined outlier readings for specific patients. Based on feedback from participating practices, clinicians also had the option to receive consolidated alert emails during office hours. Clinicians were responsible for reviewing their patients' blood pressure data and for making appropriate treatment changes.

The intervention included both clinician and patient education. Project staff prepared participating clinicians and their teams for successful implementation of SMBP monitoring through train-the-trainer sessions, in-person technical assistance, and webinars. Tools (e.g., blood pressure technique posters, hypertension control protocol) were distributed to support clinician knowledge of and adherence to best practices. All participating patients received education on SMBP and hypertension management during their onboarding session.

Outcomes

To measure the feasibility of the SMBP intervention, we analyzed the following: how frequently participants measured their blood pressure using the device, participant knowledge of proper blood pressure measurement technique, whether they found the blood pressure devices easy to use, whether they trusted the measurements, whether they felt their medications were changed as a result of the SMBP program, whether they felt their ability to manage their blood pressure had increased, and if they experienced any barriers to using the devices. We also assessed feasibility from the practice's perspective by analyzing how many alerts clinicians received, whether clinicians acted on the SMBP values, if they felt the alerts were burdensome, if they trusted the blood pressure measurements, if they felt the SMBP program

accelerated blood pressure control, and if they would recommend other practices use the SMBP devices with their patients. Since this is a feasibility study, the efficacy of the intervention at lowering blood pressure is not reported here.

Data Sources and Analytic Plan

The patient screening form collected key patient characteristics: gender, date of birth, height, weight, self-reported race and ethnicity, languages spoken at home, level of education attained, and type of health insurance. The portal database included blood pressure measurements for each recruited patient, alerts generated by outlier measurements, and actions taken by clinicians in response. Data on patients' knowledge about taking blood pressure measurements came from a pre/post onboarding assessment administered by project staff. These onboarding assessments were administered during the first six months of the intervention, before onboarding responsibilities shifted from project staff to the practices themselves.

We also analyzed patients' and practices' responses to electronic evaluations about their experiences using the intervention. Practices completed this experience evaluation three and five months after implementing the intervention at their site; patients completed it after six months of participation in the SMBP program.

We calculated descriptive statistics using Microsoft Excel. The researchers had access to the dataset through their work at Healthcentric Advisors implementing the SMBP program. The intervention and analysis was funded by Healthcentric Advisors. This study was reviewed and approved by the Lifespan Institutional Review Board.

RESULTS

Project staff recruited 17 outpatient primary care sites, including community health centers, a solo practitioner, academic practices, and multispecialty private practices. Participating practices referred more than 500 patients with uncontrolled hypertension for the program. During the study period, 187 patients were fully on-boarded into the SMBP intervention (Table 1). Just over half the participants were male (56%), more than two-thirds were 50 years or older (71%), and most were White (83%). Half had a college or professional degree (54%). It took an average of seven calls and one in-person visit to fully onboard a patient.

Patient Feasibility

By their fourth week of participation, two-thirds of participants consistently monitored their blood pressure: 64% took at least 3 measurements per week, with an average of 7.6 measurements per patient during week 4 (Table 2). Among the 94 patients who took both the pre- and post-onboarding knowledge assessments, 88% either demonstrated improved knowledge or maintained a perfect score. Among the 63 patients who completed the experience evaluation, 92% agreed that it is easy to use the home blood pressure

Table 1. Patient Characteristics (N=187)

Characteristics	% (n)
Female	44% (69)
Age, years	
21-49	29% (49)
50-65	44% (75)
Over 65	27% (47)
BMI over 30	66% (110)
Race*	
Black or African American	6% (9)
White	83% (123)
Multiple races	5% (8)
Other	6% (9)
Ethnicity*	
Hispanic or Latino/a	4% (6)
Speak a language other than English at home	13% (21)
Education level	
Less than high school diploma	6% (7)
High school diploma	25% (32)
Some college	15% (19)
College degree	31% (39)
Graduate or professional degree	24% (30)
Type of health insurance	
Medicare or Medicare Advantage	28% (45)
Medicaid	9% (15)
Dual coverage with Medicare/Medicaid	2% (3)
Commercial	60% (97)
No insurance	1% (2)

*Self-reported

BMI = body mass index

Totals for each variable may not sum to 187 due to missing data.

monitor, and 90% agreed that they trust the blood pressure measurements they take themselves. Three-quarters of patients felt that their physician practice was making more frequent modifications to their regimen in response to their home blood pressure readings. Overall, 79% of patients reported an increased ability to manage their blood pressure (Table 2).

In the open-ended responses to the experience evaluation, patients expressed appreciation for the SMBP program and described positive impacts, such as increased motivation to control their blood pressure, more consistent adherence to their medications, and increased awareness of their diet and exercise routines. About half of respondents (48%) described barriers, most commonly challenges in finding time to take

Table 2. Patient Feasibility Outcomes (N=187)

Outcome Measure	% (n)
Patients regularly self-monitoring their blood pressure after 4 weeks*	64% (120)
Mean number of SMBP measurements per patient during fourth week of participation	7.6 measurements
Patient knowledge related to SMBP and hypertension management improved after onboarding education**	88% (83)
Patients who agreed with the following statements:***	
It is easy to use the blood pressure monitor.	92% (58)
I trust the blood pressure measurements that I take myself.	90% (57)
I feel that my physician practice is making more frequent modifications to my treatment in response to my home BP readings.	75% (47)
Since participating in the SMBP Pilot, I feel more able to manage my blood pressure.	79% (50)

* Defined as at least 3 measurements per week.

** Includes patients with perfect scores both before and after onboarding. Denominator for knowledge assessment = 94.

*** Denominator for experience evaluation = 63.

SMBP = self-measured blood pressure

measurements or following their practice's recommended schedule for measuring, and difficulty using the technology for the app or the monitor.

Practice Feasibility

In total, 153 patients triggered 1,849 alerts, out of 29,361 total blood pressure measurements during the 15-month study period. Patients averaged 3.8 alerts overall during their first four weeks of participation. About half of the alerts were "high" (between 160/100 mm Hg and 180/110 mm Hg), 37% were "low" (below 100/60 mm Hg), and 11% were considered "critical high" (above 180/110 mm Hg) (Table 3). The number of alerts each week decreased over patients' first four weeks of participation (Figure 1). During the entire study period, practice staff documented 409 actions in response to the alerts, with calls to patients as the most common action. On average, clinicians documented 1.4 actions per patient during the patient's first four weeks of participation.

Among the seven clinicians and practice staff who completed the practice experience evaluation, all agreed that the SMBP program accelerated the process of blood pressure control for their patients, and that they would recommend this SMBP program to other practices. Most (six out of seven) clinicians and practice staff agreed that the alerts received through the SMBP program were more beneficial than burdensome, and that they felt comfortable making treatment changes based on home blood pressure readings received through the portal. Three comments noted that support staff sign into the portal, which makes it less burdensome to clinicians that the SMBP information is separate from their electronic health record (EHR).

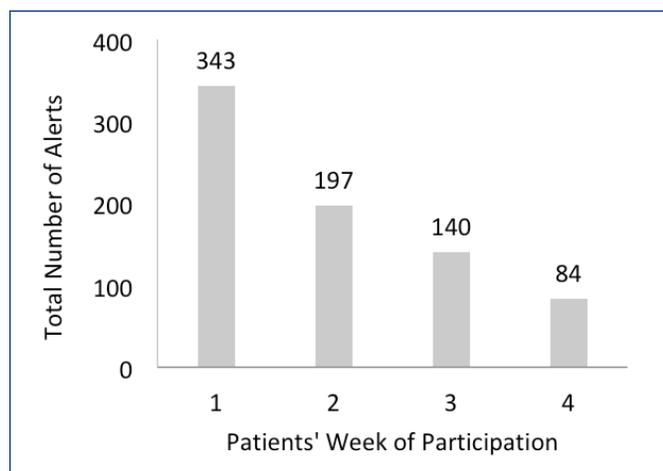
Table 3. Practice Feasibility Outcomes

Outcome Measure	Number
Total number of blood pressure measurements	29,361
Total number of alerts during study period*	1,849
Low blood pressure (< 100/60)	688
High blood pressure (160/100 – 180/110)	962
Critical high blood pressure (> 180/110)	199
Clinician actions**	409
Calls to patients	186
Medication changes	90
Messages to patients through medical record	63
Continued monitoring	51
Other***	50

* Blood pressure values included here for reference are the default alert settings. Clinicians could customize the parameters that defined outlier readings for specific patients. All blood pressures are given in mm Hg.

** Clinicians may document more than one category per action (e.g., medication change and call to patient).

*** Other actions included, for example, reporting of alerts to other practice staff and discussions with patients during previously scheduled visits.

Figure 1. Total Alerts by Patients' Week of Participation

DISCUSSION

We found that engaging patients in an SMBP program that provides practices with real-time access to home blood pressure measurements was feasible for both patients and practices. Nearly two-thirds (64%) of patients regularly monitored their blood pressure four weeks into the program, with an average of 7.6 measurements per week. In terms of patient experience, 92% of patients felt the blood pressure monitor was easy to use, and 79% reported an increased ability to manage their blood pressure.

Clinical documentation showed that practice staff reviewed patients' blood pressure data and made adjustments to medications between office visits. During patients' first month of participation, clinicians received an average of 3.8 alerts per patient and documented an average of 1.4

actions per patient. The greatest number of alerts were generated in the first week of patient participation and then decreased substantially. Improvement in blood pressure over several weeks may have contributed to the decrease in alerts, as well as clinicians' ability to adjust the values that triggered alerts for specific patients. The subset of clinicians who responded to the practice experience evaluation trusted the home blood pressure measurements, felt the SMBP program accelerated blood pressure control, felt the alerts were more beneficial than burdensome, and would recommend other practices use the SMBP devices with their patients.

An important element of the feasibility of this program from practices' perspective was the involvement of both clinicians and other practice staff. Multiple practice staff members could be given access to the online SMBP portal, which facilitated timely response to patients' blood pressure readings. Flexibility in who could monitor the portal made practices more amenable to implementing the program; they were usually able to identify a staff member in their practice who could devote a few hours per week to blood pressure management. In particular, a practice-based pharmacist is able to make suggestions regarding medication changes and to send a new prescription to the pharmacy.

Our results are consistent with literature on the importance of combining SMBP with additional support for patients with hypertension.^{10,11} A systematic review comparing SMBP to no self-monitoring found that self-monitoring was only effective when accompanied by additional clinical support, such as medication titration, education, or lifestyle counseling. We observed evidence of enhanced clinical support in our SMBP program (e.g., between visit communication among patients and practice staff, medication changes), as well as sustained patient engagement. In addition, the intervention included patient education, which may be responsible for patients' self-reported increase in their ability to manage their blood pressure.

The recent growth of telemedicine underscores the importance of remote patient monitoring.¹² Many factors support remote monitoring of blood pressure, including collection of data in the environment where patients spend most of their time, more frequent measurements which strengthens the accuracy of the blood pressure readings,¹³ greater patient engagement in their care, leading to better medication adherence,¹⁴ and reduction of clinical inertia on the part of primary care physicians.¹⁵ The COVID-19 pandemic has expanded the use of telemedicine to the care of chronic conditions, making remote patient monitoring an important tool in managing hypertension.

While our study has several strengths, the findings should be considered in the context of the following limitations. The patient participants in this SMBP program were mostly White, well-educated, and commercially insured, which may affect generalizability to other patient populations. The practices that opted to participate are likely different than practices that decline to participate in these types of pilot programs. For example, the participating practices may have

more clinical staff to support physicians and better infrastructure. In addition, there was a small number of responses to the practice experience evaluation and a relatively small proportion of patient participants enrolled at the time of the patient experience evaluation.

Our results offer lessons for future SMBP and other remote monitoring programs. Extensive effort was required to recruit patients into the program, including referrals from practices, EHR messaging and letters via US mail to promote participation, and outreach calls. Patients who had discussed the SMBP program with their clinician prior to outreach calls were much easier to engage, illustrating the importance of clinician involvement in recruiting patients and conveying the value of home blood pressure measurements. Participating practices found that recruitment was less time-consuming when conducted in the context of an office visit, when introducing the program to the patient took just a few minutes. Strategies to promote recruitment of diverse participants are also needed, so as not to exacerbate the digital divide in health care.¹⁶ While project staff had hoped to include a greater number of patients from populations disproportionately impacted by hypertension, only 17% of the participants in this pilot were non-White.

In conclusion, this study demonstrates the feasibility of a program combining SMBP with real-time access to home blood pressure measurements by outpatient practices. Patients regularly used the blood pressure monitors and found them easy to use, clinicians adjusted medications based on patients' blood pressure data, and practices would recommend the SMBP program to others. Given the observed medication titration, we anticipate that participants would have improvements in their blood pressures; future studies should assess whether patients achieved better blood pressure control after participating in this type of SMBP program.

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Disclaimer

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