AAMS General Medicine
ISSN: 2834-7140 (Print) | eISSN: 2834-7141 (Online)
Volume 07, Issue 10, Pages 16-30
DOI: 10.4103/aams.0498029
ORIGINAL ARTICLE

Home Blood Pressure Monitoring and Short-Term Hypertension Control: A Simulated Comparative Study

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Received: 2026-08-27 · Accepted: 2026-09-12

Abstract

Background: Hypertension frequently remains uncontrolled despite effective treatment options. Home blood pressure monitoring may strengthen patient engagement and provide clinicians with measurements beyond occasional clinic visits. Objective: To illustrate how a structured monitoring intervention could be evaluated using a transparent, internally consistent synthetic dataset. Materials and Methods: This educational simulation represented 80 adults with uncontrolled hypertension, divided equally between structured home monitoring and usual care over eight weeks. The intervention combined twice-daily home measurements, weekly telephone support, and medication reminders. Both groups continued their existing prescriptions. Clinic blood pressure was represented by the average of three standardized readings. Outcomes included systolic pressure change, attainment of clinic pressure below 140/90 mmHg, and self-reported medication adherence. All observations were constructed; no patients were recruited or examined. Results: Mean systolic pressure decreased from 152 to 138 mmHg in the monitoring group and from 151 to 145 mmHg with usual care. The corresponding reductions were 14 and 6 mmHg, producing an illustrative between-group difference of 8 mmHg. Control was achieved by 24 of 40 monitoring participants and 14 of 40 usual-care participants. Reported adherence increased by 20 and 5 percentage points, respectively. No uncertainty estimates or significance tests were calculated because the dataset did not represent sampled clinical observations. Conclusion: The example demonstrates a practical framework for evaluating supported home monitoring. Its numerical findings are hypothetical and cannot establish effectiveness, safety, or generalizability. A prospective, ethically approved study would be required before drawing clinical conclusions.

Keywords: hypertension, home monitoring, blood pressure, medication adherence, primary care, synthetic data

1. Introduction

Hypertension is a major modifiable contributor to cardiovascular and kidney disease, yet sustained blood pressure control remains difficult to achieve in routine clinical practice. Although effective antihypertensive medications are widely available, treatment outcomes depend on more than prescribing an appropriate drug regimen. Patients must obtain medicines consistently, understand treatment instructions, incorporate daily dosing into established routines, and continue therapy despite the frequently asymptomatic nature of elevated blood pressure. These demands make medication adherence an important consideration in the long-term management of hypertension.

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Medication adherence is a dynamic behavior influenced by individual, treatment-related, and health-system factors. Limited understanding of hypertension, concerns about adverse effects, forgetfulness, complex dosing schedules, and financial constraints may each interfere with regular medication use. Communication between patients and clinicians can also shape expectations regarding the benefits and duration of treatment. In primary care, where hypertension is commonly diagnosed and monitored, identifying these barriers may help clinicians distinguish inadequate medication use from other explanations for uncontrolled blood pressure, including suboptimal prescribing, measurement variability, or secondary causes.

Health literacy may be particularly relevant because successful self-management requires patients to interpret medication labels, follow dosing instructions, recognize potential adverse effects, and navigate follow-up care. However, knowledge alone does not necessarily translate into consistent adherence. A patient may understand the importance of treatment but remain unable to purchase medication or attend appointments. Conversely, practical support from family members or simplified prescribing may facilitate adherence despite limited understanding of medical terminology. Evaluating health literacy alongside social and clinical characteristics may therefore provide a more informative picture than examining any single determinant in isolation.

The relationship between adherence and blood pressure control also requires cautious interpretation. Self-reported adherence can be affected by recall errors and a tendency to provide socially desirable responses. Clinic blood pressure measurements may not fully represent usual blood pressure, particularly when assessment procedures are inconsistent or out-of-office monitoring is unavailable. Furthermore, associations observed at one point in time cannot establish whether a particular barrier preceded poor adherence or developed in response to treatment difficulties. These limitations underscore the value of standardized measurements and clearly defined analytical objectives in observational research.

The present cross-sectional study was designed to examine the association between medication adherence and blood pressure control among adults receiving antihypertensive treatment in primary care. Secondary objectives were to assess whether health literacy, medication burden, perceived adverse effects, and reported access difficulties were associated with lower adherence. By combining standardized clinic blood pressure assessment with structured patient-reported measures, the study seeks to identify potentially modifiable barriers relevant to everyday practice. The findings are intended to inform the development of feasible, patient-centered interventions and generate hypotheses for prospective studies, rather than establish causal relationships or determine the effectiveness of any specific adherence strategy.

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Figure 2. Figure 1. Standardized seated blood pressure measurement with supported back, feet flat, and arm at heart level.

2. Materials and Methods

A prospective, parallel-group, randomized controlled study will evaluate whether structured home blood pressure monitoring combined with brief nurse-led education improves blood pressure control compared with usual care among adults with uncontrolled essential hypertension. The study will be conducted in two urban primary care clinics, with follow-up lasting 12 weeks. Recruitment will begin only after approval by the responsible institutional ethics committee and prospective trial registration. All participants will provide written informed consent before study-specific procedures.

Eligible participants will be adults aged 30–75 years with documented essential hypertension, prescribed antihypertensive treatment for at least three months, and a mean screening office systolic blood pressure of 140–179 mmHg. Treatment must have remained unchanged during the preceding four weeks. Exclusion criteria will include suspected secondary hypertension, pregnancy, cardiovascular events within six months, dialysis-dependent kidney disease, clinically significant arrhythmia preventing reliable oscillometric measurement, or inability to perform home measurements without assistance. Individuals with blood pressure requiring urgent assessment will receive appropriate clinical referral rather than enrollment.

Potential participants will be identified through clinic appointment lists and approached consecutively by research staff. Baseline assessment will record age, sex, educational attainment, smoking status, diabetes, cardiovascular history, medication use, and hypertension duration. Height, weight, and waist circumference will be measured using standardized procedures. Medication names, doses, and subsequent changes will be verified against clinical records whenever possible. Self-reported adherence will be assessed by asking how many prescribed antihypertensive doses were missed during the preceding seven days.

Office blood pressure will be measured using validated automated upper-arm devices with appropriately sized cuffs. Participants will avoid smoking, caffeine, and exercise for 30 minutes beforehand and rest seated for five minutes, with back supported, feet flat, and arm positioned at heart level. Three readings will be obtained one minute apart; the mean of the final two readings will define office blood pressure. The same procedure will be repeated at weeks 6 and 12, preferably at a similar time of day.

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Participants will be allocated equally to intervention or usual care using computer-generated randomization with variable block sizes, stratified by clinic. Allocation will be concealed through sequentially numbered, opaque, sealed envelopes prepared by an independent researcher. Participants and intervention nurses cannot be blinded, but outcome assessors and the primary analyst will remain unaware of allocation.

Intervention participants will receive a validated home monitor and a 30-minute individual session covering measurement technique, medication-taking routines, dietary salt reduction, and physical activity consistent with clinical advice. They will take two morning and two evening readings, one minute apart, on seven consecutive days before each follow-up visit. Nurses will provide telephone reinforcement at weeks 2 and 4. Usual-care participants will continue routine clinic management. Treatment decisions in both groups will remain with treating clinicians. Participants will receive instructions for seeking care for concerning symptoms or repeated markedly elevated readings; medication self-adjustment will not be advised.

The primary outcome will be between-group difference in office systolic blood pressure at week 12, adjusted for baseline values. Secondary outcomes will include diastolic blood pressure, office control below 140/90 mmHg, missed medication doses, and adverse events. A sample of 150 participants, allowing 15% attrition, will provide approximately 80% power to detect a 6-mmHg difference, assuming a standard deviation of 12 mmHg and a two-sided significance level of 0.05.

Analyses will follow the intention-to-treat principle. Linear regression will adjust the primary comparison for baseline systolic pressure and clinic. Effect estimates will include 95% confidence intervals. Missing primary outcomes will be addressed using multiple imputation when its assumptions are defensible, with complete-case sensitivity analysis. Secondary analyses will be considered exploratory. Data will be stored in a password-protected database using coded identifiers, with access restricted to authorized study personnel.

3. Results

The following results describe a hypothetical randomized study of pharmacist-supported hypertension management versus usual care; the numerical findings are constructed for manuscript development and do not represent verified patient observations. The study evaluated whether structured medication review, adherence counseling, and home blood pressure monitoring were associated with improved systolic blood pressure over 12 weeks in adults with uncontrolled essential hypertension.

Of 340 patients screened, 240 were enrolled and randomized equally between the intervention and usual-care groups. Among the 100 patients not enrolled, 61 did not meet eligibility criteria, 23 declined participation, and 16 could not attend scheduled assessments. Week-12 blood pressure measurements were available for 114 intervention participants and 112 usual-care participants, corresponding to retention rates of 95.0% and 93.3%, respectively. Six intervention participants and eight usual-care participants lacked final measurements. All 240 randomized participants were included in the primary intention-to-treat analysis using multiple imputation for missing outcomes.

Baseline demographic and clinical characteristics were broadly similar between groups (Table 1). Mean age was approximately 58 years, and women accounted for slightly more than half of participants. Mean baseline systolic blood pressure was 151.8 mmHg in the intervention group and 152.1 mmHg in the usual-care group. Diabetes was present in approximately one-quarter of participants, while mean estimated glomerular filtration rate was above 75 mL/min/1.73 m^2 in both groups. Participants were taking an average of approximately two antihypertensive medications at enrollment.

Table 1. Baseline characteristics of randomized participants

Characteristic	Intervention (n = 120)	Usual care (n = 120)
Age, years, mean ± SD	58.4 ± 10.2	57.9 ± 10.8
Women, n (%)	64 (53.3)	66 (55.0)
Body mass index, kg/m^2, mean ± SD	29.1 ± 4.6	28.8 ± 4.9

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Systolic blood pressure, mmHg, mean ± SD	151.8 ± 10.7	152.1 ± 11.0
Diastolic blood pressure, mmHg, mean ± SD	91.2 ± 7.8	90.8 ± 8.1
Diabetes mellitus, n (%)	31 (25.8)	29 (24.2)
Estimated glomerular filtration rate, mL/min/1.73 m^2, mean ± SD	78.6 ± 17.9	79.4 ± 18.5
Antihypertensive medications, number, mean ± SD	1.8 ± 0.7	1.9 ± 0.8

At week 12, mean systolic blood pressure among participants with available measurements was 136.2 mmHg in the intervention group and 143.5 mmHg in the usual-care group. In the imputed primary analysis, mean reductions were 15.6 and 8.6 mmHg, respectively. After adjustment for baseline systolic blood pressure, the between-group difference was −7.1 mmHg (95% confidence interval [CI], −10.0 to −4.2; P < 0.001), favoring the intervention. A complete-case analysis produced a similar adjusted difference of −7.0 mmHg (95% CI, −10.1 to −3.9).

Secondary outcomes generally followed the same direction (Table 2). The adjusted difference in diastolic blood pressure was −3.0 mmHg (95% CI, −4.8 to −1.2). Among participants assessed at week 12, blood pressure below 140/90 mmHg was achieved by 69 of 114 intervention participants and 44 of 112 usual-care participants. The unadjusted absolute difference was 21.2 percentage points (95% CI, 8.5 to 33.9). Secondary analyses were exploratory and were not adjusted for multiple comparisons.

Table 2. Blood pressure outcomes and adverse events through week 12

Outcome	Intervention	Usual care
Week-12 systolic pressure, mmHg, mean ± SD, observed cases	136.2 ± 12.1	143.5 ± 13.0
Systolic pressure change, mmHg, imputed mean	−15.6	−8.6
Week-12 diastolic pressure, mmHg, mean ± SD, observed cases	82.8 ± 7.4	85.5 ± 8.0
Blood pressure below 140/90 mmHg, n/N (%)	69/114 (60.5)	44/112 (39.3)
Any reported adverse event, n/N (%)	18/120 (15.0)	15/120 (12.5)
Symptomatic hypotension, n/N (%)	5/120 (4.2)	3/120 (2.5)

Intervention delivery was largely completed as scheduled. Of the 120 assigned participants, 108 attended all three pharmacist consultations, eight attended two, and four attended only the initial consultation. Home monitoring records covering at least eight study weeks were submitted by 101 participants. Medication intensification was documented in 38 intervention participants and 24 usual-care participants. These process measures were descriptive and did not establish which intervention component accounted for the observed blood pressure difference.

Any adverse event was reported by 18 intervention participants and 15 usual-care participants. Symptomatic hypotension occurred in five and three participants, respectively; none of these episodes required hospitalization. Two serious adverse events occurred, one in each group, and neither was judged related to study procedures. No deaths were recorded during follow-up. The small number of events limited comparisons of safety outcomes.

Exploratory analyses showed blood pressure differences favoring intervention among participants with and without diabetes and among those younger than 60 years and those aged 60 years or older. Confidence intervals for subgroup interaction estimates included zero, providing insufficient evidence of differential effects. Findings were limited to the 12-week observation period; persistence of blood pressure improvement and effects on cardiovascular events were not assessed.

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4. Discussion

In this illustrative primary care cohort, greater adherence to prescribed antihypertensive medication was associated with better blood pressure control over six months. The association remained evident after accounting for measured demographic and clinical characteristics, although its magnitude was attenuated following adjustment. Patients reporting difficulty obtaining medication or managing complex regimens also appeared less likely to achieve sustained control. These findings support the clinical relevance of adherence while emphasizing that hypertension management depends on more than prescribing an effective drug. Because the study was observational, the results should be interpreted as associations rather than evidence that improving adherence alone would necessarily produce the observed differences in blood pressure.

The direction of the principal association is biologically plausible. Consistent medication use helps maintain therapeutic exposure and may reduce periods during which blood pressure is insufficiently treated. However, adherence is not a uniform behavior: occasional missed doses, prolonged treatment interruptions, and inconsistent timing may have different consequences depending on the medication and its duration of action. The adherence measure used in this cohort could not fully distinguish these patterns. Consequently, patients classified within the same adherence category may have experienced different levels of pharmacological protection. This measurement limitation may partly explain why some participants reporting good adherence nevertheless had uncontrolled blood pressure at follow-up.

The persistence of uncontrolled hypertension among apparently adherent patients also highlights the importance of evaluating treatment adequacy. An insufficient dose, an inappropriate combination of agents, delayed treatment intensification, or an unrecognized secondary cause may contribute to poor control. Dietary sodium intake, alcohol consumption, sleep-disordered breathing, and medications that increase blood pressure are additional potential influences. These factors should not be interpreted as competing explanations that diminish the importance of adherence. Rather, they illustrate why clinicians should avoid attributing every elevated measurement to patient behavior. A structured review of measurement technique, prescribed therapy, medication-taking practices, and relevant comorbidities is more informative than an adherence assessment in isolation.

The observed relationship between medication access difficulties and poorer control suggests that structural barriers may influence outcomes alongside individual preferences. Even when patients understand the purpose of treatment, transportation costs, unreliable pharmacy supplies, competing household expenses, and difficulties attending appointments can interrupt care. Counseling alone is unlikely to resolve these problems. The findings therefore provide a rationale for evaluating practical approaches such as longer prescription durations, coordinated refills, and affordable medication options. Nevertheless, this study did not test these interventions directly. Their effectiveness, feasibility, and unintended consequences would need assessment within the local healthcare system before routine adoption could be recommended.

Regimen complexity provides another clinically relevant interpretation of the findings. Patients taking several medications at different times may face greater organizational demands, particularly when hypertension coexists with diabetes, cardiovascular disease, or other chronic conditions. Simplifying treatment could reduce this burden, but the observed association between complexity and poor control is susceptible to confounding by disease severity. Patients with more difficult hypertension are also more likely to require multiple agents. It would therefore be inappropriate to conclude that additional medications themselves caused worse outcomes. Where clinically suitable and affordable, once-daily dosing or fixed-dose combinations may be considered, while preserving the flexibility required for safe titration.

Several methodological issues affect the interpretation of this cohort. Self-reported adherence is vulnerable to recall error and socially desirable responses, potentially leading participants to overestimate medication use. If this misclassification occurred similarly across outcome groups, it could weaken the observed association; differential reporting could introduce bias in either direction. Clinic blood pressure measurements also cannot fully characterize usual blood pressure exposure. Although standardized measurement procedures can reduce variability, transient stress, recent

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activity, and visit timing may still influence readings. Home or ambulatory monitoring would help distinguish sustained uncontrolled hypertension from a white-coat effect and identify patients whose clinic readings underestimate their usual blood pressure.

Residual confounding remains an important limitation despite statistical adjustment. Health literacy, depression, cognitive function, dietary practices, and continuity of care may influence both adherence and blood pressure outcomes, yet may not have been measured sufficiently. A healthy-adherer effect is also possible: individuals who consistently take medication may engage in other beneficial behaviors that contribute to better control. Conversely, adverse effects or perceived lack of benefit may lead patients with difficult-to-control hypertension to discontinue treatment, creating bidirectional relationships. Follow-up over six months establishes some temporal structure but does not eliminate these possibilities. The analysis therefore cannot isolate the independent causal contribution of medication adherence with certainty.

Selection and follow-up processes may further limit generalizability. Patients who attend routine primary care visits may differ from those who remain outside regular care, particularly regarding access, motivation, and underlying risk. If participants with the greatest treatment difficulties were also more likely to miss follow-up, the observed burden of uncontrolled hypertension could be underestimated. The relatively short observation period additionally prevents conclusions about durable blood pressure control or cardiovascular events. Nevertheless, examining adherence alongside access barriers and treatment complexity offers a clinically useful perspective on everyday hypertension care. Future studies should combine longitudinal adherence measures, repeated out-of-office blood pressure assessment, and explicit evaluation of missing outcomes. Pragmatic randomized trials could then test whether interventions addressing identified barriers improve control without increasing adverse effects or treatment burden. Overall, these findings support a patient-centered, system-aware approach to hypertension management while leaving the effectiveness of specific corrective strategies to be established.

Figure 1. Figure 2. Upper-arm cuff positioning and alignment over the brachial artery during home monitoring.

5. Conclusion

This observational study suggests that structured follow-up, patient education, and regular blood pressure monitoring may support better hypertension management in primary care. The observed

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association between consistent follow-up and improved blood pressure control highlights the potential importance of continuity of care alongside appropriate pharmacological treatment. However, these findings should be interpreted as associations rather than evidence that any individual component of care directly caused the observed differences.

The results support a patient-centered approach that considers medication adherence, lifestyle practices, and practical barriers to accessing care. Clear explanations of treatment goals, opportunities to discuss adverse effects, and individualized advice on dietary sodium intake and physical activity may help patients participate more effectively in long-term management. Home blood pressure monitoring may also provide useful information when validated devices and appropriate measurement techniques are available. Its value nevertheless depends on clinical interpretation and timely communication between patients and healthcare professionals.

Several limitations restrict the strength and generalizability of these conclusions. The observational design leaves room for residual confounding, including differences in baseline cardiovascular risk, health literacy, socioeconomic circumstances, and motivation to engage with care. Self-reported adherence and lifestyle behaviors may be affected by recall and reporting bias. Furthermore, changes in blood pressure over the study period cannot establish whether the care approach reduces cardiovascular events or produces sustained benefits beyond follow-up.

Future research should evaluate these components through adequately powered prospective studies, ideally incorporating randomized comparisons, standardized blood pressure assessment, and longer observation periods. Outcomes should include treatment burden, adverse events, equity of access, and cost-effectiveness, in addition to blood pressure control. Overall, the study provides a rationale for further evaluation of accessible, coordinated hypertension care while emphasizing that implementation decisions should remain responsive to local resources, patient preferences, and the limitations of the available evidence.

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