Effectiveness of Home Blood Pressure Monitoring Among Low-Income Adults in Rural Appalachia

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Context: High blood pressure (BP) is a common chronic condition in the United States. For many people, BP control through pharmacologic intervention alone is not effective at maintaining a healthy BP. Team-based, patient-focused care and home-based BP monitoring in addition to pharmacologic interventions have been shown to be effective for controlling BP.

Objective: To determine the effectiveness of the hypertension management program at the Heritage Community Clinic in Athens, Ohio.

Methods: Medical records of 43 patients who took part in the hypertension management program were retrospectively reviewed and included clinical data such as age, sex, BP, body mass index, comorbidities, family history, and demographic information. In addition to standard pharmacologic interventions, the program provided equipment for at-home BP monitoring, education on behavior and lifestyle modification, and 5 follow-up visits. Data from the 5 follow-up visits were analyzed.

Results: Linear mixed-effects regression models of BP suggested that the visit factor was significantly associated with BP ($P<.001$). On average at each visit, patients showed a 6.8–mm Hg reduction in systolic BP and a 3.8–mm Hg reduction in diastolic BP after controlling for demographic variables. General stress level, marital status, and depression were all significantly associated with BP ($P<.05$). In addition, 67.5% of the patients who took part in this program achieved the target treatment guidelines of the Eighth Joint National Committee for hypertension management.

Conclusion: A clinic-based hypertension management program comprising patient education, support, medication, and home BP monitoring was effective at reducing BP.

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High blood pressure (BP) is the most common chronic condition in the United States in adults aged 20 years or older, and it accounts for estimated annual costs over $50 billion.[1] The American Heart Association defines high BP in this age group as greater than 140/90 mm Hg.[1] Patients with high BP or hypertension (≥140/90 mm Hg) have been shown to be at increased risk for cardiovascular disease.[2] However, proper control of hypertension through pharmacologic intervention alone has been shown to be limited, with only modest improvement reported.[3] Previous studies[4,5] have shown team-based, patient-focused care to be effective in managing hypertension. Home-based BP monitoring, with nurse- or pharmacist-led care, has also been shown to be an effective method to manage hypertension.[6] According to one meta-analysis,[7] home BP monitoring resulted in a 10% greater chance of reaching BP targets when compared with standard care.

The Heritage Community Clinic (HCC) is a free medical clinic run by the Ohio University Heritage College of Osteopathic Medicine in Athens. Patients are seen at the main clinic on the university's campus or through its mobile health clinic, which travels to various sites throughout the HCC service area. The clinic serves uninsured and underinsured patients aged 18 to 64 years whose family income falls below 200% of the federal poverty line. Sixty-eight percent of the population served by HCC live in a rural area that contains some of the most poverty-stricken counties in the state of Ohio.[8] The median household income ranges from a high of $42,834 (Washington County)[9] to a low of $33,823 (Athens County).[10] The average percentage of households with an education level of at least a high school diploma attainment ranges from a high of 89.4% (Athens County) to a low of 83.4% (Meigs County), compared with the state average of 88.5%.[8] In an attempt to better manage hypertension among the population it serves, the HCC, with assistance of the Athens Foundation, implemented a hypertension management program.

The aim of the current study was to assess the effectiveness of the HCC hypertension management program in reducing BP and controlling hypertension. We conducted a secondary analysis to determine what other variables (eg, demographics, medical history, lifestyle) may have influenced patient outcomes.

Methods

This retrospective medical record analysis was conducted to assess the effectiveness of HCC's hypertension management program in controlling and reducing hypertension. We obtained approval for this study from the Ohio University Institutional Review Board.

The data of interest were patients' age, sex, body mass index (BMI), BP readings and dates of readings, comorbid diabetes or high cholesterol, medications, diet, caffeine intake, alcohol intake, tobacco use, anxiety, self-reported stress level, self-reported depression, marital status, education level in years, family history of heart disease and hypertension, and education and recommendations by a nurse practitioner. Diabetes, high cholesterol, and anxiety were established on the basis of a diagnosis in the medical record. Self-reported stress had been assessed by asking patients to report their general stress level as low, medium, or high. Self-reported depression had been assessed by asking patients whether they felt depressed.

Hypertension Management Program

Patients consented to participate in the program by signing an authorization to treat. A registered nurse and nurse practitioner were available to answer any questions before patient consent. A certified nurse practitioner was the primary clinician in the program's staff. All participants received a complete physical examination and assessment of their medical history before participating in the program. In addition to standard pharmacologic intervention, the program provided patients with at-home BP monitoring equipment and 5 follow-up visits to track and monitor their BP. The nurse practitioner provided one-on-one education on behavioral and lifestyle changes that influence hypertension management, as well as educational materials and logs for tracking their BP. Blood pressure was recorded at the initial visit (baseline) and at 5 follow-up visits.

Statistical Analysis

Linear mixed-effects regression (LMER) models with an identification variable included as the random effect were used. The LMER models included a random intercept and fixed effects of visit factor, sex, age, BMI, diabetes, high cholesterol, anxiety, self-reported stress level, self-reported depression, marital status, education level, and family history of heart disease and hypertension. Two models were fit to systolic BP (SBP) and 2 models were fit to diastolic BP (DBP) data. Model 1 included the visit factor and basic demo-

graphic variables (sex, age, BMI, and education in years). Model 2 additionally included diabetes, high cholesterol, anxiety, self-reported stress level, self-reported depression, marital status, and family history of heart disease and hypertension. Owing to the explanatory nature of the study, *P* values were not adjusted. The significance level for all tests were set at .05 (2-tailed). Data were presented as mean (SD) for continuous variables and frequency (% total) for categorical variables. The statistical computing program R (R Foundation for Statistical Computing) was used for all analyses.

Results

Of the 50 patients who participated in the program, we were able to analyze the results of 43 patients, owing to attrition. Two-thirds of the patients were women (65%) and one-third (35%) were men (mean [SD] age, 52.75 [7.53] years). The mean (SD) BMI was 36.3 (8.13). Education level among patients was as follows: 4.7% had not graduated from high school, 62.8% had a high school diploma, 20.9% had an associate's degree, and 11.6% were classified as other.

The LMER models of SBP are presented in the *Table*. Model 1 suggests that the visit factor was significantly associated with SBP ($P<.001$). At each visit, patients showed a 6.8-point mean reduction in SBP, after controlling for the demographic variables in the model (*Figure 1*). None of the demographic variables predicted the baseline SBP. Model 2 found 2 statistically significant factors: general stress level and marital status. Specifically, after controlling for the other factors in the model, patients who reported a high level of stress had lower SBP than those who reported a low level of stress by 16.0 mm Hg ($P<.05$) (*Figure 2*). Also, compared with single patients, married patients had higher SBP (*Figure 3*) by 14.7 mm Hg ($P<.05$).

The LMER models of DBP are summarized in the *Table*. Model 1 suggests that patients showed a statistically significant reduction in DBP at each visit (mean, 3.8 mm Hg; $P<.001$), after controlling for the demographic variables in the model (*Figure 1*). Besides the visit factor, none of the basic demographic variables had predicted the baseline DBP. Model 2 suggests 1 significant factor: depression. After controlling for the other factors in the model, patients with self-reported depression had higher DBP than nondepressed patients by 8.0 mm Hg ($P<.05$).

Patients had a mean BP of 150/98 mm Hg at intake and a mean follow-up BP of 128/85 mm Hg. Paired sample *t* tests revealed a statistically significant reduction in SBP and DBP ($P<.001$) relative to intake. Patients had an average reduction of 22 mm Hg in SBP and 13 mm Hg in DBP.

Discussion

The management of hypertension often focuses on pharmacologic therapy to achieve effective control. The HCC program recognizes that treatment for patients with hypertension may require more than medication. The complexity of hypertension management in the program takes into consideration the whole person, focusing on many determinants of health, including psychological and social issues, lifestyle, and comorbid medical conditions. Our results suggest that holistic health care can result in greater improvements in BP than medications alone.

In a meta-analysis by Uhlig et al,[4] self-measured BP monitoring was found to reduce BP independent of additional interventions. A statistically significant reduction in BP was observed at each visit in the current study (*Figure 1*). Of the patients who took part in this program, 67.5% achieved Eighth Joint National Committee target treatment guidelines for hypertension management, which is higher than the national average of 56.4%.[11] Further investigation into the program's success is warranted.

A BP reduction as small as 2 mm Hg has been shown to reduce the risk of cardiovascular events by up to 10%.[12]

Table.
Statistical Models of Systolic and Diastolic Blood Pressure Outcome Comparisons After a Hypertension Management Program (N=43)[a]

	Systolic		Diastolic	
Variable	**Model 1**	**Model 2**	**Model 1**	**Model 2**
Intercept	127.85[b] (21.37)	136.51[b] (25.20)	92.00[b] (14.12)	89.62[b] (17.30)
Visit	−6.75[b] (0.92)	−6.56[b] (0.96)	−3.80[b] (0.54)	−3.75[b] (0.56)
Body Mass Index	0.25 (0.26)	0.07 (0.28)	0.10 (0.17)	0.05 (0.19)
Male Sex	2.70 (4.45)	6.04 (4.68)	1.41 (2.93)	1.46 (3.23)
Age	0.29 (0.27)	0.03 (0.37)	0.06 (0.18)	0.06 (0.25)
Education Level, y	−0.44 (1.23)	0.59 (1.26)	−0.29 (0.81)	0.28 (0.87)
General Stress Level				
Low vs medium	…	−14.23 (7.89)	…	−5.44 (5.54)
Low vs high	…	−16.04[c] (7.51)	…	−6.15 (5.24)
Marital Status				
Single vs married	…	14.74[c] (6.18)	…	6.80 (4.30)
Single vs divorced	…	4.19 (6.99)	…	1.80 (4.86)
Single vs widowed	…	11.39 (12.82)	…	4.79 (9.10)
Anxiety	…	−5.13 (6.63)	…	−6.51 (4.55)
Depression	…	8.05 (5.57)	…	7.97[c] (3.85)
High Cholesterol	…	6.59 (6.78)	…	−0.93 (4.61)
Diabetes Mellitus	…	−4.67 (5.47)	…	−4.12 (3.78)
Family History of Heart Disease	…	−3.55 (5.20)	…	−4.72 (3.58)
Family History of Hypertension	…	6.14 (4.38)	…	2.64 (3.04)
Akaike Information Criterion	1217.05	1225.02	1070.45	1080.91
No. of Observations	142	142	142	142

[a] Data are presented as β (SE) except where otherwise noted. Model 1 included the visit factor and basic demographic variables (ie, body mass index, sex, age, and education level). Model 2 additionally included general stress levels, marital status, anxiety, depression, high cholesterol, diabetes mellitus, and family histories of heart disease and hypertension.
[b] $P<.001$.
[c] $P<.05$.

From intake to visit 5, patients participating in this program had an average SBP reduction of 22 mm Hg and DBP reduction of 13 mm Hg. Randomized controlled trials have found a 25% to 40% reduction in lifetime risk for death due to cardiovascular disease and stroke by reducing BP by 10 mm Hg.[13]

Determinants of self-care by patients with chronic diseases have been associated with both socioeconomic and psychological factors.[14] All patients in the current study had a household income below 200% of the federal poverty line and were uninsured or underinsured.

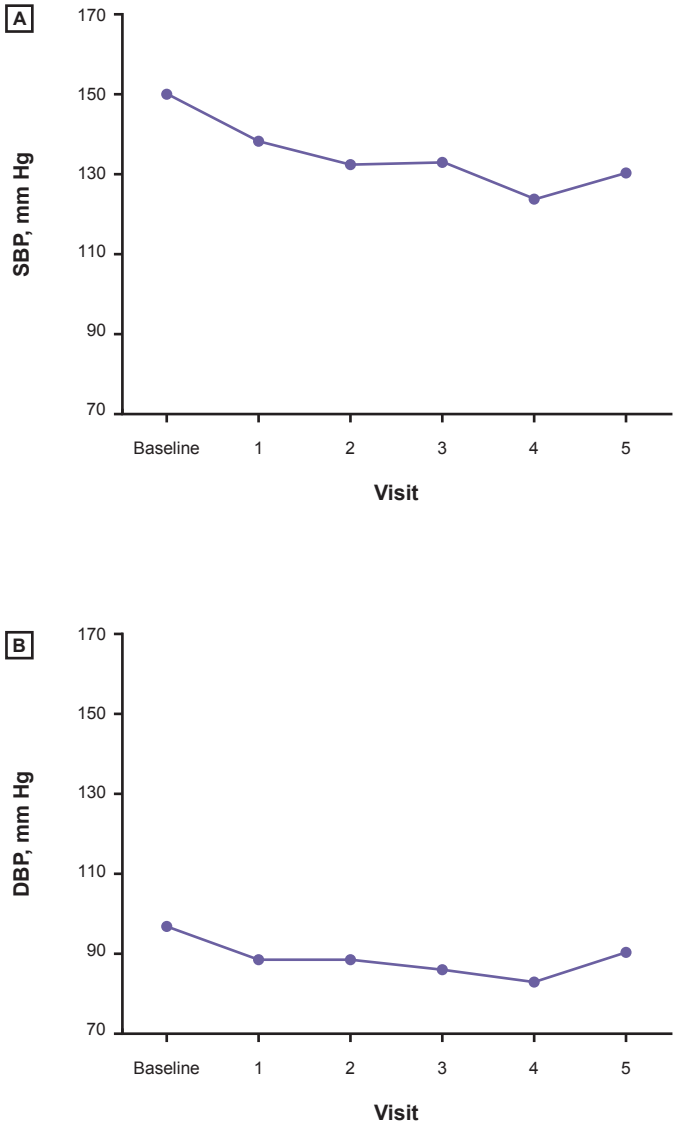

Figure 1.
Mean systolic blood pressure (SBP) (A) and diastolic blood pressure (DBP) (B) among patients participating in a hypertension management program at baseline and 5 follow-up visits (N=43). The number of follow-up visits was associated with a significant decrease in SBP (mean, 6.8 mm Hg; *P*<.001) and DBP (mean, 3.8 mm Hg; *P*<.001) at each visit.

Stress has been shown to have an effect on the development of hypertension.[15] We were surprised to find that self-reported stress had an inverse relationship with SBP, with high-stressed patients having a lower SBP than low-stressed patients (*Figure 2*). One reason for this finding could be the potential bias of self-reported measures. Marital status also had a statistically significant effect on SBP, with married patients having a higher SBP than single patients (*Figure 3*). Patients with higher scores on measures of depression had lower levels of knowledge and awareness regarding hypertension.[16] Depression is also associated with lower adherence rates to self-measured BP monitoring programs.[16] We found higher rates of self-reported depression to be associated with increased DBP.

This study has several limitations. Although the improvement in patient outcomes after the program was statistically significant compared with pharmacologic intervention alone, without a control group, we are unable to determine what part (or parts) of the intervention—medication, home BP monitoring, follow-up visits, or education on behavior and lifestyle modification—contributed to the improved outcomes. Owing to a lack of sufficient population parameters, we were unable to conduct a power analysis to estimate the required sample size. Because this study was a retrospective medical record analysis, we used data from all available patients. Another limitation is that we relied on self-reports of depression and stress level.

The combined effects of home BP monitoring, one-on-one education, and regular follow-up visits as an adjunct to medication warrants further investigation. The HCC's hypertension management program represents an archetype worth emulating in other rural and underserved areas in Appalachia. Future research should focus on better understanding the individual influence each of these factors has on BP outcomes, as well as how these factors interact to produce improved BP. A pilot study investigating the complex interactions between HCC's osteopathic manipulative medicine clinic and the hypertension management program is being considered.

Conclusion

As an adjunct to medication, regular follow-up appointments with a clinician, and education on lifestyle changes, home BP monitoring may be an effective method of managing hypertension in medically underserved, low-income rural populations. The results of this study support the implementation of hypertension management programs in rural and impoverished areas of Appalachia. Further investigation into the use of home BP monitoring among this population and other similar populations is warranted.

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Author Contributions

All authors provided substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; all authors drafted the article or revised it critically for important intellectual content; all authors gave final approval of the version of the article to be published; and all authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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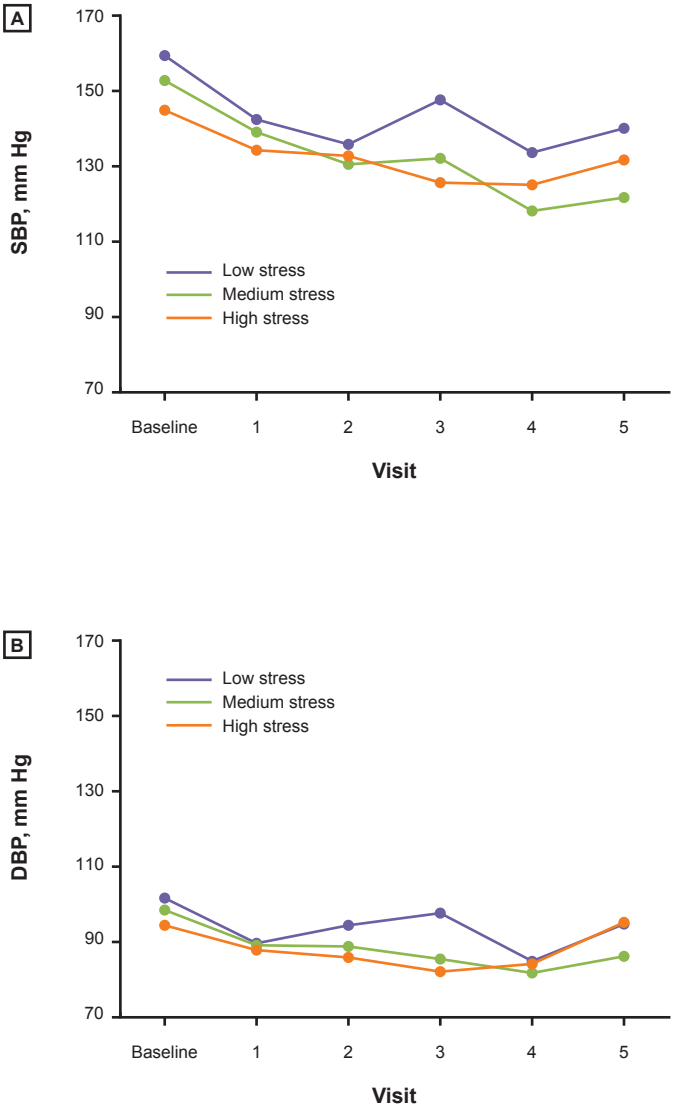

Figure 2.
Systolic blood pressure (SBP) (A) and diastolic blood pressure (DBP) (B) by stress level among patients participating in a hypertension management program at baseline and 5 follow-up visits (N=43). A greater decrease in SBP was observed in high-stressed patients compared with low-stressed patients (mean, 16.0 mm Hg; $P<.05$). No statistically significant reduction in DBP was observed across stress levels.

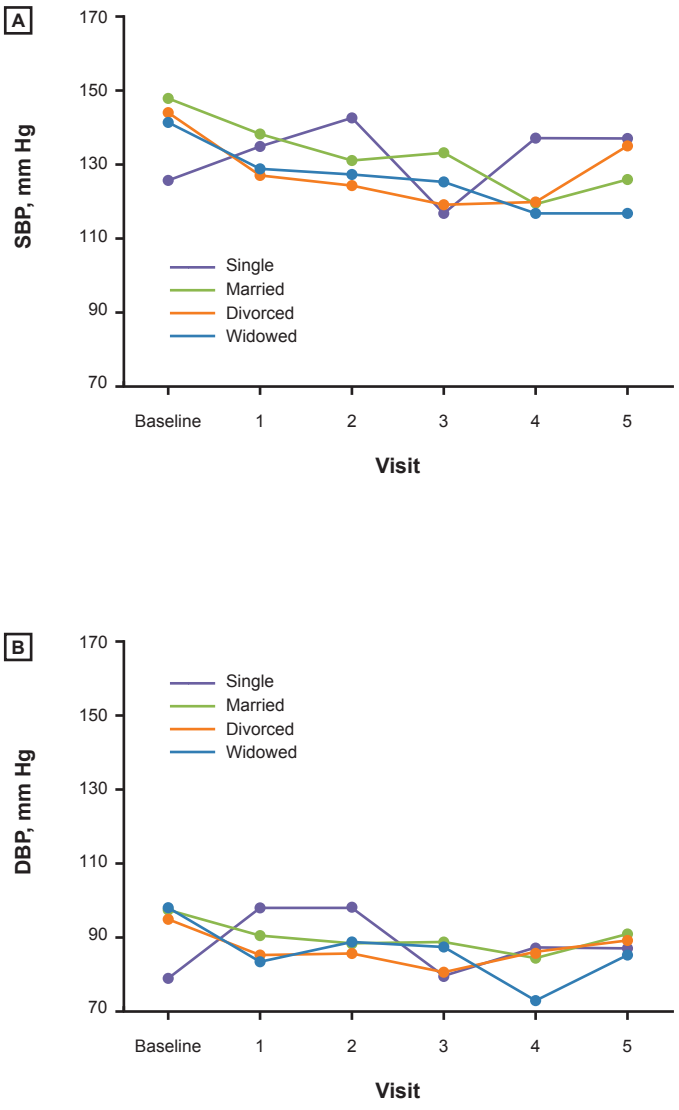

Figure 3.
Systolic blood pressure (SBP) (A) and diastolic blood pressure (DBP) (B) by marital status among patients participating in a hypertension management program at baseline and 5 follow-up visits (N=43). When compared with single patients, married patients had higher SBP by 14.7 mm Hg (P<.05). No statistically significant reduction in DBP was observed across marital statuses.

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