ORIGINAL ARTICLE

Racial Differences and Social Determinants of Health in Achieving Hypertension Control

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Abstract

Objective: To investigate whether specific social determinants of health could be a "health barrier" toward achieving blood pressure (BP) control and to further evaluate any differences between Black patients and White patients.

Patients and Methods: We conducted a retrospective cohort study of 3305 patients with elevated BP who were enrolled in a hypertension digital medicine program for at least 60 days and followed up for up to 1 year. Patients were managed virtually by a dedicated hypertension team who provided guideline-based medication management and lifestyle support to achieve goal BP.

Results: Compared with individuals without any health barriers, the addition of 1 barrier was associated with lower probability of control at 1 year from 0.73 to 0.60 and to 0.55 in those with 2 or more barriers. Health barriers were more prevalent in Black patients than in those who were White (44.6% [482 of 1081] vs 31.3% [674 of 2150]; $P<.001$). There was no difference at all in BP control between Black individuals and those who were White if 2 or more barriers were present.

Conclusion: Patient-related health barriers are associated with BP control. Black patients with poorly controlled hypertension have a higher prevalence of health barriers than their White counterparts. When 2 or more health barriers were present, there was no differences in BP control between White and Black individuals.

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Hypertension affects nearly 1 in 2 US adults and is a major modifiable risk factor for cardiovascular disease (CVD).[1,2] In fact, more CVD events in the United States have been attributed to hypertension than any other modifiable risk factor.[3] In 2017, hypertension accounted for 23 deaths per 100,000 population, but it was markedly higher in Black Americans at 54.1 deaths per 100,000 men and 37.8 per 100,000 women.[4,5] Controlling blood pressure (BP) levels via medication and/or lifestyle change reduces the risk for CVD and all-cause mortality among adults with hypertension, yet only 44% of US hypertensive adults have their hypertension controlled to a BP of less than 140/90 mm Hg and just 24% achieve a BP of 130/80 mm Hg or lower.[3,6,7] What is equally concerning is that these trends have deteriorated since 2013-2014 when BP control rates peaked at 54%, leading the US Surgeon General to recently declare hypertension control an urgent national priority.[2,3]

Many factors have been reported to influence hypertension control, including those attributed to the health care professional (adherence to guidelines, bias, time, therapeutic inertia) and to the patient (medication adherence, access to health care, resistant hypertension).[8-11] There is little data, however, evaluating other social determinants of health factors that may influence hypertension control including health literacy, patient activation, and financial stress. We sought to evaluate the relationship of these potential "health barriers" on hypertension control in hypertensive patients

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with poorly controlled BP in a large digital hypertension program in which care delivery was close to uniform.

PATIENTS AND METHODS

Consecutive patients with hypertension were enrolled by their physician into a digital management program during an office encounter or through an offer letter by their physician. Patients were required to possess a smartphone as well as purchase a wireless BP unit from a list of preselected vendors based on the smartphone's operating system as previously described.[12] Patients also were required to have an active account in the patient portal (MyChart; Epic Systems Corporation), which was free; if patients did not have an active account, they were given the opportunity to sign up for one.

Program details, questionnaires, and electronic consent to participate took place online through MyChart. Questionnaires assessed factors related to hypertension including dietary sodium and alcohol consumption, depression, medication adherence, physical activity, and screening for obstructive sleep apnea.[12] Additional information that impacts chronic disease management was collected, including patient activation, which measures an individual's willingness and ability to take independent actions to manage their health and care, utilizing patient activation measures.[13,14] Health literacy, defined as the degree to which individuals have the capacity to obtain, communicate, process, and understand basic health information needed to make appropriate decisions, was assessed using the single item literacy screener.[15] Financial stress over the cost of their medications was assessed via a single question: "Do you ever have trouble paying for your medication?"

Additional clinical data were obtained from the electronic medical record, including serum sodium, potassium, and creatinine levels, estimated glomerular filtration rate, thyroid function test results, and body mass index (calculated as weight in kilograms divided by height in meters squared). These data were used to create a patient phenotype that assisted in the design of the intervention process.

Patients were asked to take no less than one BP reading per week but were encouraged to take 3 to 4 per week. Each BP reading was automatically transmitted into the electronic medical record via a Bluetooth connection to the patient portal on their smartphone. If the care team had not received a BP reading for 8 days, patients would receive an automated text alerting them that a BP measurement was needed. The BP units were purchased and initial training and setup were provided at the Ochsner O Bar, a patient-facing service that provides information, training, and technical support for patients interested in apps, wearables, and connected home devices.[16] Doctoral pharmacists and health coaches participated in the intervention that included education, drug management, and lifestyle recommendations according to hypertension guidelines.[6]

Pharmacists contacted patients by phone and discussed treatment options for improving BP control. Patients were encouraged to be an active participant in their hypertension management and worked with the pharmacist to cocreate the treatment plan by choosing among various lifestyle and medication options. If medication affordability was identified, efforts were made to substitute low-cost generics and utilize lower-cost pharmacies. Similarly, if depressive symptoms were identified, referral was made per the enrolling physician's preferences to either primary care or psychiatry for further evaluation and management.

Patients were also directed to a dedicated hypertension website that offered further educational and lifestyle materials including custom videos and downloadable handouts. Patients received monthly reports detailing their progress along with lifestyle tips. Physicians also received monthly reports on their patients' progress. Incoming BP data were analyzed via internally developed algorithms regarding validity and directional change, and alerts were established to highlight which patients needed which intervention and when.

TABLE. Characteristics of Patients Enrolled in the Digital Medicine Program for Hypertension for at Least 60 Days, Stratified by Number of Barriers to Health Care[a,b,c]

Variable	Total patients (N=3305)	Barriers to health care[d] 0 (n=2117)	1 (n=841)	2-3 (n=347)
Age (y), mean ± SD	62.2±12.9	62.3±12.7	61.7±13.2	63.0±13.6
Female	1835 (55.5)	1139 (53.8)	480 (57.1)	216 (62.2)
Race				
Black	1081 (32.7)	599 (28.3)	314 (37.3)	168 (48.4)
White	2150 (65.1)	1476 (69.7)	502 (59.7)	172 (49.6)
Other/unknown	74 (2.2)	42 (2.0)	25 (3.0)	7 (2.0)
BP (mm Hg), mean ± SD				
Systolic	144.9±11.8	144.6±11.5	144.6±12.0	147.2±13.3
Diastolic	84.8±9.3	85.0±9.1	84.4±9.6	84.4±9.9
BMI (kg/m^2), mean ± SD[e]	33.2±7.2	32.7±6.8	33.8±7.4	34.7±8.0
Creatinine (mg/dL), mean ± SD[e]	1.00±0.36	0.99±0.29	1.02±0.31	1.07±0.66
eGFR (mL/min/1.73 m^2), mean ± SD[e]	59.1±7.6	59.6±7.5	58.4±7.4	57.6±8.7
LDL (mg/dL), mean ± SD[e]	106.3±43.4	107.3±41.4	104.5±45.4	104.5±49.9
HDL (mg/dL), mean ± SD[e]	51.2±13.8	51.9±14.1	50.2±13.3	49.3±12.9
Total cholesterol (mg/dL), mean ± SD[e]	179.0±37.8	180.9±37.4	176.3±36.9	173.3±41.2
Glucose ≥126 mg/dL[e]	607 (18.4)	340 (16.1)	175 (20.8)	92 (26.5)
HbA_{1c} ≥6.5 (% of total hemoglobin)[e]	555/1753 (31.7)	294/1044 (28.2)	166/476 (34.9)	95/233 (40.8)
Days enrolled				
60-89	90 (2.7)	55 (2.6)	19 (2.3)	16 (4.6)
90-179	381 (11.5)	225 (10.6)	105 (12.5)	51 (14.7)
180-364	751 (22.7)	470 (22.2)	197 (23.4)	84 (24.2)
≥365	2083 (63.0)	1367 (64.6)	520 (61.8)	196 (56.5)
Months enrolled, mean ± SD	19.7±14.0	20.1±14.0	19.2±13.7	18.3±14.2
Months enrolled, median (IQR)	16 (9-26)	16 (9-27)	15 (8-26)	14 (7-25)

[a]BMI, body mass index; BP, blood pressure; eGFR, estimated glomerular filtration rate; HbA_{1c}, hemoglobin A_{1c}; HDL, high-density lipoprotein cholesterol; IQR, interquartile range; LDL, low-density lipoprotein cholesterol.

[b]Data are presented as No. (percentage) of patients unless indicated otherwise.

[c]SI conversion factors: To convert creatinine values to μmol/L, multiply by 88.4; to convert LDL, HDL, and total cholesterol values to mmol/L, multiply by 0.0259; to convert glucose value to mmol/L, multiply by 0.0555; to convert HbA_{1c} values to proportion of total hemoglobin, multiply by 0.01.

[d]Barriers to health care defined by medium or high risk for (1) financial strain, (2) health illiteracy, and/or (3) patient inactivation.

[e]Missing values for BMI (n=251), creatinine (n=277), eGFR (n=279), LDL (n=613), HDL (599), total cholesterol (n=598), and glucose (n=282) were imputed via multiple imputation using all available baseline data; missing HbA_{1c} was not imputed due to high levels of missing data (n=1552 [47.0%]).

Outcomes

The primary outcome was the proportion of patients with controlled BP, defined as a BP of less than 140/90 mm Hg at 365 days in the program. We additionally sought to define any differences in health barriers and BP control between Black patients and those who were White.

Statistical Analyses

To assess improvements in BP control, the patient sample for analysis was restricted to those with uncontrolled BP (above 140/90 mm Hg) at the time of enrollment in the digital medicine program. Further inclusion criteria for analysis were (1) recorded indicators of barriers to health care (financial

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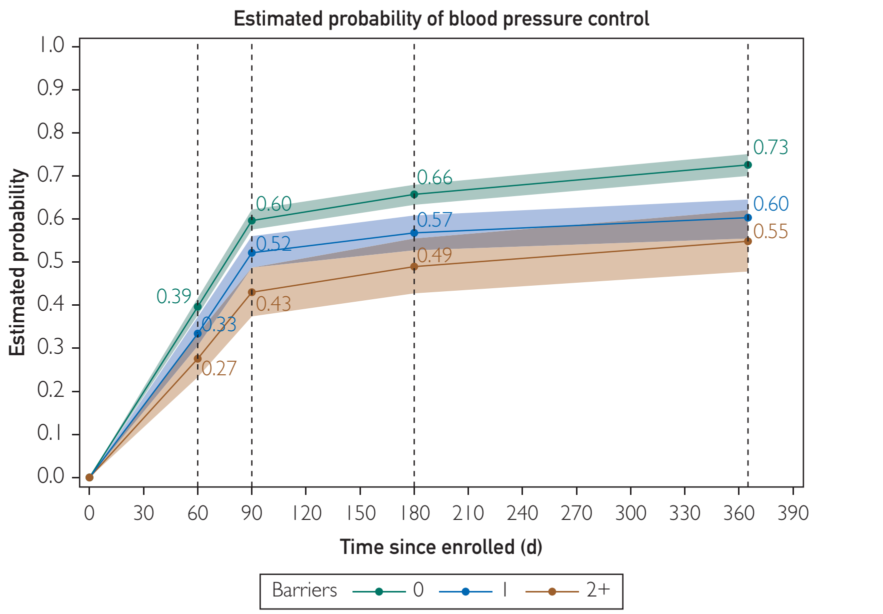

FIGURE 1. Estimated probability of blood pressure control according to number of barriers to health care.

strain, health illiteracy, and patient inactivation) and (2) enrollment in the hypertension digital medicine program for at least 60 days. Patient characteristics are summarized in the Table for the entire sample and by study group defined as number of barriers to health care (0, 1, or 2 to 3). Continuous measures are presented as mean ± SD or as median and interquartile range. Categorical measures are presented as frequencies and percentages. Using a generalized linear mixed model approach, a logistic regression model for repeated measures was constructed to estimate and make comparisons of BP control at 60, 90, 180, and 365 days following enrollment in the program. The multivariate outcome in the model is made up of binary indicators of BP control at each follow-up time point. The model incorporates fixed, categorical effects for the study group and time along with the 2-way interaction. These fixed effects function to categorize each observed outcome by study group and number of days postenrollment. Including the interaction term allows for estimation of the probability of BP control at 60, 90, 180, and 365 days for groups of patients with 0, 1, and 2 to 3 health barriers. A random patient effect is included to account for within-patient correlation over time, and an unstructured correlation matrix is specified. No additional covariates were included in the model. An additional model was constructed to investigate race. Only Black and White patients were included in this subsequent analysis because of a limited sample size of patients of other races. The generalized linear mixed model was modified to include an indicator of patient race and all interactions of race, group, and time. All analyses were carried out using SAS statistical software, version 9.4 for Windows (SAS Institute), and all confidence intervals and *P* values are adjusted for multiple comparisons via simulation-based methods.

RESULTS

We identified 3305 patients who met the inclusion criteria for this investigation, 1188 (35.9%) of whom described at least 1 health barrier and 347 (10.5%) having 2 or more health barriers. Additional characteristics of patients as well as groupings based on the

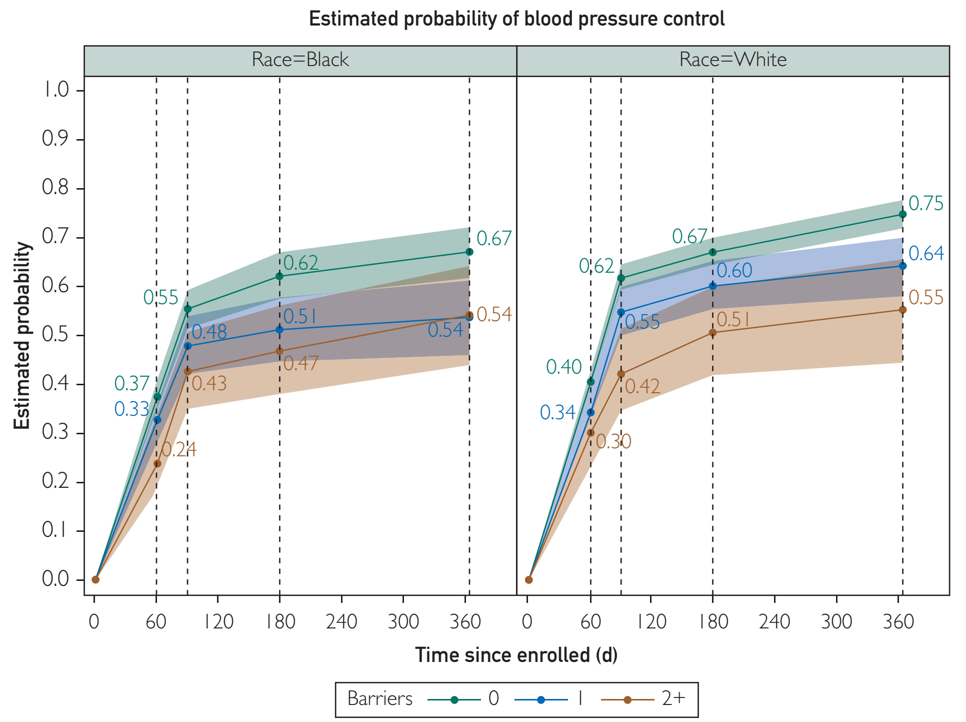

FIGURE 2. Estimated probability of blood pressure control according to number of barriers to health care and race.

number of health barriers are shown in the Table. Patients ranged in age from 20 to 98 years, with a mean age ± SD of 62.2±12.9 years; 1,651 (50.0%) were 65 years or older. The average body mass index was 33.2±7.2 kg/m^2, with 64.8% of the cohort (2143 of 3305 patients) classified as obese and 14.9% (494) classified as severely obese. Prior to study entry, the average duration with their primary care physician was 4.7 years and 2.4 visits per year. There were no differences between Black and White patients in baseline laboratory values (creatinine, hemoglobin A_{1c}, glucose, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, total cholesterol, triglycerides, sodium, thyrotropin, estimated glomerular filtration rate). Although Black patients comprised 32.7% of the cohort (1081 of 3305), they represented only 28.3% of patients with no health barriers (599 of 2117) while representing 48.4% of patients with 2 or more health barriers (168 of 347). Moreover, the overall presence of any health barrier and 2 or more health barriers was greater in Black than in White patients (44.6% [482 of 1081] vs 31.3% [674 of 2150], *P*<.001; and 15.5% [168 of 1081] vs 8.0% [172 of 2150], *P*<.001, respectively). Supplemental Table 1 (available online at http://www.mayoclinicproceedings.org) summarizes observed distributions of health barriers by race.

Blood pressure control was evaluated at 60, 90, 180, and 365 days, grouped by the number of health barriers. The greatest BP control was achieved at all time points in those without any health barriers compared with those with either 1 or 2 or more health barriers (Figure 1). Blood pressure control trended worse for all patients with 2 or more health barriers compared with 1 health barrier, but the difference was not statistically meaningful (Supplemental Table 2, available online at http://www.mayoclinicproceedings.org; (60 days:P=.43, 90 days:P=.07, 180 days:P=.35, 365 days:P=.87).

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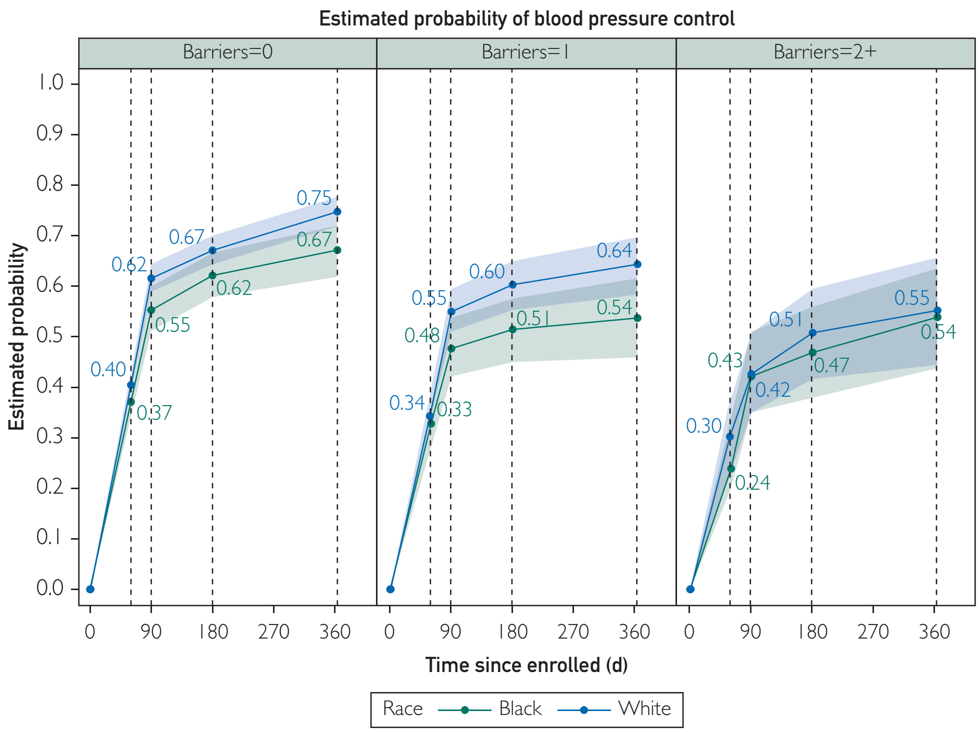

FIGURE 3. Estimated probability of blood pressure control according to number of barriers to health care and race.

Evaluation of BP control by race at each time point is summarized in Figure 2 and Supplemental Table 3 (available online at http://www.mayoclinicproceedings.org). White patients without health barriers had significant improvement in BP control at 365 days compared with White patients with either 1 or 2 or more health barriers (P= .01 and P<.01, respectively). Furthermore, there was a clear trend in BP control between 0, 1, and 2 or more health barriers among White patients at 365 days (0.75, 0.64, and 0.55, respectively). Among Black patients at 365 days, there was a trend toward better BP control in those without health barriers compared with patients with 1 or 2 or more health barriers. Moreover, at 365 days, Black patients with either 1 or 2 or more health barriers achieved the same level of BP control (0.54).

Figure 3 and Supplemental Table 4 (available online at http://www.mayoclinicproceedings.org) highlight the differences at each time point between patients who were Black and those who were White based on number of health barriers. At 365 days, BP control in patients without health barriers was better in White (0.75) vs Black (0.67) patients. White patients trended toward better BP control at 90, 180, and 365 days compared with those who were Black when there were no health barriers or only 1 health barrier identified, but these differences were not significant (P=no barriers [90 days: P=.15, 180 days: P=.57, 365 days: P=.13]; 1 barrier [90 days: P=.54, 180 days: P=.33, 365 days: P=.32]). There was no difference between patients who were Black and those who were White at all time points in BP control if 2 or more barriers were present.

DISCUSSION

There are 3 important findings from this investigation. First, social determinants of health, including difficulties with health literacy, patient activation, and financial stress, are prevalent in adults with hypertension and are associated with BP control. Second, in our cohort, the prevalence of health barriers in patients with poorly controlled hypertension was higher in Black patients compared with White patients. Finally, although BP control was compromised, we found no difference between Black patients and those who were White in BP control once 2 or more health barriers were present.

Controlling BP levels remains a high national priority because it reduces the risk for CVD and all-cause mortality among adults with hypertension, yet BP control in the US population continues to decline, with only 44% of US hypertensive adults currently having their BP controlled to a level of less than 140/90 mm Hg.[3,6,7] Although quality measures published by the American Heart Association/American College of Cardiology recommend documentation of nonclinical data in hypertensive patients, such as social determinants of health and health literacy, and suggest that future registries incorporate factors such as patient engagement and activation, no studies to date have evaluated the direct impact of these factors on BP control.[17] Independently, however, each of these health barriers has documented adverse effects on clinical outcomes.

Health literacy as noted in the Affordable Care Act is the degree to which individuals have the capacity to obtain, communicate, process, and understand basic health information needed to make appropriate decisions.[18] A watershed 2006 assessment by the US Department of Education found that only 12% of US adults had a proficient state of health literacy.[17] The majority of adults (53%) had intermediate health literacy, whereas 22% had basic health literacy and 14% exhibited below basic health literacy.[19] A low level of health literacy has been described as a "barrier to quality care" and is associated with more frequent hospitalizations, higher health care costs, and poor health outcomes.[20–23] The Affordable Care Act emphasizes patient engagement and activation as another key pillar in health policy, with abundant evidence linking better outcomes and lower costs with more engaged and activated patients.[13,14] Patient activation is not immutable, and efforts directed at improving activation result in better outcomes and lower costs. The financial stress of paying for medical care including medication has been rising, with over half of US adults worried that they would not have enough money to afford care.[24-26] Although prescription medication spending accounts for 22% of all expenditures devoted to treating individual medical conditions, it accounts for 41% among those with hypertension.[27] Individuals experiencing financial stress exhibit poor medication adherence, a leading cause of poor BP control, as well as higher rates of hospitalizations and deaths.[28-32] Medication adherence is strongly associated with social determinants, and approaches to improve medication adherence include efforts to promote patient activation, text messaging, consumer-directed care, and pharmacist-led engagement, all of which were integral features of our digital hypertension program.[33,34]

Disparities in health outcomes are prevalent when Black patients are compared with White patients, including heart disease, diabetes, cancer, maternal mortality, and infant mortality.[35-38] Hypertension prevalence and control rates mirror these differences.[39,40] Non-Hispanic Black patients (NHBs) have significantly higher rates of hypertension and lower rates of BP control than non-Hispanic White patients.[39,41] Data from the Centers for Disease Control and Prevention revealed that hypertension control rates were highest in White patients (55.7%) and lowest in NHBs (48.5%).[39] These differences are material because the attributable risk for hypertension and 30-year all-cause mortality is nearly double for NHBs when compared to with White patients.[42,43] Our study describes a higher prevalence of health barriers in Black patients that substantially contribute to poorer BP control. However, when the number of barriers present was 2 or more, the BP control rate differences between White and Black patients were eliminated, suggesting that reduced BP control reported in Black patients is more a result of socioeconomic disparities than inherent susceptibility to clinical interventions. We can only theorize that because

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Black patients have a higher prevalence of measured health barriers than their White counterparts, it is possible that additional unmeasured and potentially less potent health barriers are also more prevalent in Black compared with White individuals. This factor may explain the advantage White patients initially had in BP control when only one measured health barrier was present. However, once 2 or more measured barriers exist, the patient becomes so sufficiently impacted that no difference can be observed in BP control between White and Black patients.

There are several strengths and limitations of this study worthy of mention. A major strength of our study is the sample size and BP values over time. Additionally, our study was unique in that all patients received guideline-based care incorporating pharmacist-directed medication management coupled with lifestyle advice from a dedicated health coach, thus reducing care variation known to impact disease management and outcomes.[44-48] Moreover, there were concerted efforts to address each of these health barriers as part of the intervention, suggesting that our reported impact on BP control rates may have been more pronounced in a standard model of care delivery. We did not, however, assess health barriers over time, and it is possible that BP control at 1 year may not be reflective of contemporary health barriers. Finally, the requirement to possess a smartphone as well as purchase a wireless BP unit may have introduced some selection bias, although it would not likely lead to more health barriers and less BP control in Black than in White patients.

CONCLUSION

Patient-related health barriers are prevalent in individuals with hypertension and are associated with BP control. Black hypertensive patients are more likely than their White counterparts to experience these health barriers, which may contribute to reduced BP control. Additional research is needed to assess optimal methods that remove and/or mitigate health barriers.

POTENTIAL COMPETING INTERESTS

The authors report no competing interests.

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AUTHOR CONTRIBUTIONS

Dr Milani—conceptualization, writing/reviewing and editing; Dr Price-Haywood—writing/reviewing and editing; Dr Burton—formal analysis; Mr Wilt—data curation; Mr Entwisle—data curation; Dr Lavie—writing/reviewing and editing.

SUPPLEMENTAL ONLINE MATERIAL

Supplemental material can be found online at http://www.mayoclinicproceedings.org. Supplemental material attached to journal articles has not been edited, and the authors take responsibility for the accuracy of all data.

Abbreviations and Acronyms: **BP,** blood pressure; **CVD,** cardiovascular disease; **NHB,** non-Hispanic Black patients

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