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CLINICAL RESEARCH

Improving Blood Pressure in High-Risk Patients With CKD Using an Interdisciplinary Remote Hypertension Program

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Introduction: Interventions are needed to reduce racial and ethnic disparities in achieving blood pressure (BP) control among patients with chronic kidney disease (CKD). We determined the feasibility and effectiveness of an interdisciplinary remote patient monitoring (RPM) hypertension program in predominantly Black and Hispanic patients with CKD.

Methods: We evaluated an RPM hypertension program for patients with CKD in a New York City health system between July 2021 and October 2022. BP data were transmitted in real-time using a cellular-enabled BP device. Education on lifestyle and adherence was provided, and medications were adjusted by a nurse practitioner (NP) via telemedicine. Feasibility was quantitatively assessed as enrollment, participation, and retention at 3 months. Effect on BP was estimated as mean change in BP at 3 months and proportion with BP $<$ 130/80 mmHg at 6 months.

Results: Among 111 patients invited, 102 (91.9%) enrolled and 87 (78.4%) were retained in the program for 3 months. Median age was 61 years, 50% were female, 55.9% were Black, 35.3% were Hispanic, and median estimated glomerular filtration rate was 47.5 ml/min per 1.73 m^2. The median days per month that BP was measured ranged from 16 to 23. Mean change in systolic and diastolic BP from enrollment to 3 months was -15.0 ± 20.8 ($P < 0.0001$) and -6.7 ± 17.7 ($P = 0.0007$), respectively. By 6 months, 49.4% achieved BP $<$ 130/80 mm Hg.

Conclusion: This RPM hypertension program in patients with CKD was feasible and effective in improving BP, which is promising for increasing equity in hypertension control. Future studies evaluating long-term maintenance of BP control using this approach compared with usual care are needed.

Kidney Int Rep (2025) **10,** 1101–1110; https://doi.org/10.1016/j.ekir.2025.01.028
KEYWORDS: CKD; health equity; hypertension; interdisciplinary; telemedicine

Hypertension is the most modifiable risk factor for cardiovascular disease and premature death worldwide.[1,2] This is especially relevant to people with CKD, a group with a prevalence of hypertension that exceeds 80% and that experiences a disproportionate burden of cardiovascular events and related death compared with the general population.[3] Guidelines from the American College of Cardiology and the American Heart Association recommend a BP $<$ 130/80 mm Hg in patients with CKD; however, nationally, less than 50% achieve this target.[4] Moreover, there are significant racial and ethnic disparities in BP control in people with CKD. Numerous studies have indicated that individuals who identify as Black or Hispanic have lower rates of BP control at all stages of CKD compared with those who identify as White.[5–8] Montefiore Medical Center, located in the Bronx, New York, provides care to a predominantly urban Black and Hispanic patient population. Among patients with CKD linked to nephrology care at our institution, we found that 35% met the recommended BP target of $<$ 130/80 mm Hg using office BP measurements.

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Received 12 May 2024; revised 7 January 2025; accepted 21 January 2025; published online 27 January 2025

Numerous professional organizations recommend managing hypertension with out-of-office BP monitoring coupled with RPM and team-based care.[4,9] Interdisciplinary care, medication standardization, and frequent follow-up visits have been shown to improve BP irrespective of race or socioeconomic status.[10–12] Home BP monitoring promotes self-management and several studies have found that it is associated with improved adherence, and reduction in clinical inertia when performed in conjunction with clinical support.[13,14] Thus, a hypertension care model that combines interdisciplinary care with RPM has the potential to address important barriers to BP control, such as, limited access to care, clinical inertia, nonstandardized medication choices, and lack of integration of out-of-office BP readings into the electronic health record.[15] A small trial of patients with CKD with hypertension demonstrated an approximately 5 mm Hg greater reduction in systolic BP at 6 months using an RPM hypertension program used to usual care.[16] Although this care model has improved BP in minoritized patients without CKD,[17–20] whether it is effective for these patients with CKD in a real-world setting has not been well-studied.

As part of an initiative to improve BP in our CKD population, we identified the following 3 important drivers of BP control: (i) patient engagement in care, which is traditionally office-based; (ii) clinical management requiring frequent visits and medication intensification if BP is not at goal; and (iii) patient ability to self-manage, for example, adherence to medications and measurement of BP at home. To address these drivers and improve BP control among patients with CKD at our institution, we developed an interdisciplinary RPM hypertension program. In this study, we report the feasibility and short-term effectiveness of our program among high-risk patients with CKD who are linked to nephrology care.

METHODS

Study Design

We evaluated the feasibility and effect on BP outcomes after implementing an interdisciplinary RPM program in patients with CKD and hypertension in a large New York City health system between July 2021 and October 2022. This study was approved by the Einstein-Montefiore Institutional Review Broad (IRB #2021-13199). Patients provided verbal consent for clinical participation in the program. The need for written consent was waived because data were collected as part of routine clinical care.

Study Setting and Population

Montefiore Medical Center provides care to a predominantly Black or African American and Hispanic population, reflecting the 2 largest racial and ethnic demographics in the Bronx. Compared with the other New York City boroughs, the Bronx has the highest prevalence of hypertension and hospitalization rates because of hypertension.[21] The burden of CKD is also high in the Bronx with an incidence of end-stage kidney disease that is 30% higher than the national average.[22] In addition to a serving a minoritized population, the Bronx is one of the poorest urban counties in the USA, with 30% of households living below the federal poverty level.[23] The outpatient nephrology practice at Montefiore Medical Center follows over 5000 patients with CKD. We determined that among 3349 patients with an International Classification of Diseases diagnosis of hypertension and 3 office BP measurements within 12 months, 65% had BP above the recommended target of $<$ 130/80 mm Hg in CKD.[4]

Description of RPM Intervention

We developed our program as part of the American Heart Association National Hypertension Control Initiative.[24] We used a physician-initiated approach to enroll patients with CKD into the program in which the treating nephrologist could invite a patient to enroll in the program at an office visit. Based on clinical judgement, nephrologists referred nondialysis patients with CKD with uncontrolled office hypertension defined as 2 or more consecutive office BP readings $\geq$ 130/80 mm Hg into the program. During this feasibility study, 2 nephrologists were given the option to refer patients to the program. Patients who were enrolled in the program received an electronic upper arm cellular enabled BP device (SmartMeter, Model SBMP802-GS-001, Smart Meter Corp., New York, NY) that was approved by the US Food and Drug Administration and externally validated by the Validated Device Listing Independent Review Committee. This BP device passively transmitted BP data to a digital RPM platform every time that patients checked their BP without requiring WiFi or internet access in their homes.

At enrollment, patients were given instructions by a nurse to measure their BP in the morning before taking their morning medication and in the evening and instructed on how to perform standardized BP measurements at home. Education on lifestyle, medication review, and adherence were provided by a collaborative team of nurses and an NP. The initial televisit with the NP was a comprehensive visit (lasting 45–60 minutes) that focused on the following: (i) review of current diet and lifestyle and providing guidance on a low sodium, heart healthy diet, and physical activity based on American Heart Association recommendations; (ii) review of medication adherence and prior intolerances; and (iii) education on hypertension

complications and symptoms. During subsequent visits, diet, lifestyle, and medication adherence were briefly reviewed, and beneficial behaviors were reinforced. Medication titration or adjustments were performed during these visits if needed. Figure 1 shows the components of the program.

Standardized algorithms adopted from the American College of Cardiology and the American Heart Association guidelines were used to titrate medications if BP was above goal at the televisits (Supplementary Figures S1 and S2, and Tables S1–S3). Every 2 to 4 weeks, medications were adjusted by an NP via telemedicine under the support of a nephrologist if the BP was not at goal. After each change in medication, reassessment of BP and laboratory monitoring as appropriate was performed until BP goal was achieved. Patients were retained in the program until BP goal was achieved, based on a monthly average BP $<$ 130/80 mm Hg, for at least 1 month.

During program development, staff coverage for BP alarms for severe hypertension (BP $\geq$ 180/120 mm Hg) or hypotension (systolic BP $<$ 90 mm Hg) was discussed. Based on guideline recommendations for follow-up of patients with asymptomatic severe hypertension to confirm adherence and adjust medications if needed, patients were contacted within 24 hours by a nurse and triaged based on the presence of symptoms during program hours (Monday through Friday, 9:00 AM–5:00 PM). If symptomatic, they were recommended to go to the emergency department and if asymptomatic, a televisit was arranged with an NP within 24 hours for medication adjustment. During onboarding into the program, patients were given instructions to go to the emergency department if symptoms such as chest pain, headache, blurry vision or shortness of breath were present.

Figure 1. Interdisciplinary RPM hypertension program components. BP, blood pressure, RPM, remote patient monitoring.

Outcomes and Data Collection

Feasibility was based on previous studies that have reported adherence to RPM hypertension programs ranging from 48% to 90%.[16,25] We assessed feasibility quantitatively based on enrollment, participation, and retention in the program at 3 months. Enrollment was defined by the proportion of patients who agreed to enroll in the program. Participation was defined as the number of days per month that BP was measured. Retention was defined as the proportion of patients who continued to measure their BP at 3 months. Feasibility and acceptability were also evaluated using a patient survey (Likert scale questions). We also asked several open-ended questions that were limited in scope and intended to gather patient feedback on aspects of the program that were effective and what could be improved, as we refined our approach (Supplementary Methods). This survey was administered to a subset of patients who had been disenrolled from the program because of achieving their BP goal, withdrawal, or nonparticipation.[26] The survey was administered via telephone by 3 nephrologists who were not involved in the program and unknown to the patients. Participants were contacted in chronological order starting from the earliest enrollment in the program. A goal was set to contact at least 50% of participants who had been disenrolled from the program.

The primary effect on BP was assessed at 3 months as the following: (i) the change in BP from enrollment to 3 months and (ii) the proportion with controlled BP at 3 months. This time frame was selected because it is frequently used to evaluate BP changes in response to medication changes and lifestyle interventions. We also reported the proportion retained in the program for at least 3 months, who achieved their BP goal by 6 months. We compared the change in systolic BP and diastolic BP from the time of enrollment using the average of the first 3 RPM BP readings with the average BP at months 1, 2, and 3. Controlled hypertension was defined as the proportion of patients with a monthly average BP $<$ 130/80 mm Hg.

Adverse outcomes were extracted from the electronic health record for hypotension (defined as systolic BP $<$ 90 mm Hg); hypertension-related emergency room visits or hospitalizations; and adverse kidney outcomes, including acute kidney injury, hyperkalemia, hypokalemia, and hyponatremia while enrolled in the program. Acute kidney injury was defined as an increase in serum creatinine

of 1.5 times the baseline value at the time of enrollment.[27] Hypokalemia was defined a serum potassium < 3.5 mEq/l, hyperkalemia was defined as a serum potassium > 5.0 mEq/l, and hyponatremia was defined as a serum sodium < 135 mEq/l. When the NP initiated or intensified a medication that could adversely affect electrolytes or kidney function, the patient was instructed to go to the laboratory for measurement of a basic metabolic panel within 1 to 2 weeks of the medication change and the NP was given safety algorithms to follow (Supplementary Figures S3 and S4).

Data on demographics, comorbidities, hypertension history, number and class of antihypertensive medications, resistant hypertension (BP > 130/80 mm Hg on 3 antihypertensive medications with 1 being a diuretic), CKD stage, laboratory parameters, telemedicine visits, emergency department visits, and hospitalizations related to hypertension were extracted from the electronic health record. RPM data were extracted on BP measurements, alarms, as well as number of days and times per month that BP was measured.

Statistical Analysis

Categorical variables were reported as frequencies and proportions. Continuous variables were reported as medians with interquartile range (nonnormally distributed) and mean with SD (normally distributed). Paired *t* tests were used to compare the BP change from enrollment to 1, 2, and 3 months and the change in medication number from enrollment to 3 months. A 2-sided alpha < 0.05 was considered statistically significant. Data analyses were performed using STATA version 17.0 (Stata Corp, College Station, TX).

RESULTS

Patient Characteristics

From July 24, 2021 to October 14, 2022, 111 patients were invited to participate in the program. Of the 111 patients invited, 102 were enrolled and 87 were retained in the program at 3 months (Figure 2). Among those who enrolled in the program, the median age was 61 years; 50% self-identified as female, 55.9% self-identified as Black and 35.3% as Hispanic (Table 1). The majority (~53%) had stage G3 CKD with a median estimated glomerular filtration rate of 47.5 ml/min per 1.73 m^2. Nearly half of them had diabetes and the majority had long-standing hypertension and were on multidrug therapy (mean number of antihypertensive medications was 2.8 ± 1.3). At enrollment, mean office systolic BP was 151.9 ± 16.9 mmHg and diastolic BP was 83.4 ± 11.1 mm Hg. Resistant hypertension was present in 46%.

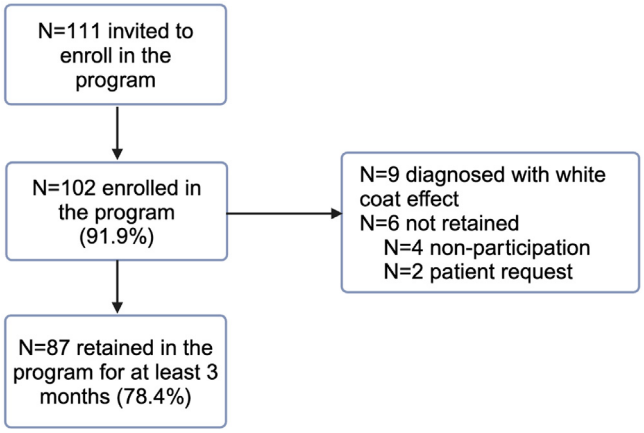

Figure 2. Patient enrollment and retention in the program.

Feasibility

Eighty-seven of 102 patients (85%) were retained for at least 3 months in the program. Of the 15 patients not

Table 1. Baseline characteristics of patients who enrolled in the RPM program (*n* = 102)

Characteristics	Value
Age, years, median (IQR)	61 (52–69)
Gender, *n* (%)	
Male	51 (50)
Female	51 (50)
Race/ethnicity, *n* (%)	
Non-Hispanic Black	57 (55.9)
Hispanic	36 (35.3)
Asian	3 (2.9)
Other/unknown	6 (5.9)
CKD stage, *n* (%)	
G2	25 (24.5)
G3a	29 (28.4)
G3b	25 (24.5)
G4	17 (16.7)
G5	6 (5.9)
eGFR, ml/min per 1.73 m^2, median (IQR)	47.5 (33–59)
Urine albumin/creatinine, mg/g, median (IQR)	154 (19.5–742)
Comorbidities, *n* (%)	
Diabetes	47 (46.1)
Cardiovascular disease	26 (25.6)
Hypertension history	
Office systolic blood pressure, mm Hg, mean (SD)	151.9 (16.9)
Office diastolic blood pressure, mm Hg, mean (SD)	83.4 (11.1)
Hypertension duration, years, median, (IQR)	10 (6, 15)
Number of antihypertensive medications, mean (SD)	2.8 (1.3)
Resistant hypertension, *n* (%)	47 (46)
Antihypertensive medication class, *n* (%)	
ACEi or ARB	69 (68)
Calcium channel blocker	72 (71)
Loop or thiazide diuretic	55 (54)
Potassium-sparing diuretic	11 (11)
Beta blocker	51 (52)
Alpha blocker	8 (8)
Centrally acting vasodilator	16 (16)

ACEi, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; CKD, chronic kidney disease; IQR, interquartile range; eGFR, estimated glomerular filtration rate; RPM, remote patient monitoring.

retained for 3 months, 9 were diagnosed with white coat effect and 6 were not retained and were disenrolled because of nonparticipation or patient request. Among the 87 patients who were enrolled in the program for at least 3 months, the median number of days per month that BP was measured decreased from 23 days in the first month to 16 days in the third month. Most patients attended at least 1 televisit per month with the NP and overall attendance for scheduled televisits was 79%.

Patient Reported Experience

Sixty-one patients (60%) who participated in the program were contacted by telephone and asked to participate in a brief survey. Of those contacted, 44 (72%) participated, 2 (3%) declined, and 15 (15%) were unable to be reached by telephone after at least 2 attempts. More than 80% were very satisfied with the nurse and NP visits, more than 70% thought that the televisit setting was appropriate, and 90% reported no technical difficulties using the BP device (Table 2). Importantly, the majority thought that it was easy to incorporate BP monitoring into their daily routine and many reported that the program led to changes in how they manage their hypertension and helped them to better manage their hypertension. Factors that made it easy for patients to participate included receiving a free BP device, text reminders to measure their BP, and scheduled visits to review BP readings. Most patients reported that they continued to measure their BP several times per week after disenrollment.

Effectiveness

The mean reduction in systolic BP from enrollment to 3 months for those retained in the program for at least 3 months was 15.0 ± 20.8 mm Hg ($P < 0.0001$), and the mean diastolic BP reduction was 6.7 ± 17.7 mm Hg ($P = 0.0007$) (Figure 3 and Tables 2 and 3). By 6 months, 43 of 87 (49.4%) who were retained in the program for at least 3 months achieved a monthly average BP < 130/80 mm Hg. We observed lower rates of BP control by worsening CKD stage. Proportionally, 11 of 21 (52.3%) with CKD stage G2, 24 of 48 (50%) with CKD stage G3, 7 of 15 (46.7%) with CKD stage G4, and 1 of 3 (33%) with CKD stage G5 were able to achieve a BP target < 130/80 mm Hg (Figure 4). At 3 months, there was an increase in the number of antihypertensive medications from 2.8 to 3.2 ($P < 0.001$). Proportionally, diuretics and calcium channel blockers were the antihypertensive medication classes that increased the most from enrollment to 3 months (Supplementary Table S1). Diuretic usage increased by 12% and calcium channel blocker usage increased by 9%.

Table 2. Patient feasibility survey ($n = 44$)

How satisfied were you with the nurse visits?	
• Very satisfied	36 (81.8)
• Satisfied	5 (11.3)
• Neutral	2 (4.5)
• Dissatisfied	1 (2.3)
• Very dissatisfied	0 (0.0)
How was the frequency of phone calls?	
• Too often	9 (20.4)
• Just right	32 (72.8)
• Not often enough	3 (6.8)
How was the setting of the visits?	
• Appropriate	31 (70.5)
• I would have liked in person better	8 (18.2)
• I would have liked over a video better	5 (11.3)
How satisfied were you with the nurse practitioner visits?	
• Very satisfied	39 (88.6)
• Satisfied	2 (4.5)
• Neutral	3 (6.8)
• Dissatisfied	0 (0.0)
• Very dissatisfied	0 (0.0)
How was the frequency of the televisits?	
• Too often	2 (4.5)
• Just right	36 (81.8)
• Not often enough	6 (13.6)
How was the setting of the televisits?	
• Appropriate	31 (70.5)
• I would have liked in person better	11 (25.0)
• I would have liked over a video better	2 (4.5)
Did you have any technical difficulties with the BP machine?	
• No	40 (90.9)
• Yes	4 (9.1)
How has it been trying to incorporate BP measuring into your daily routine?	
• Very easy	27 (61.4)
• Easy	11 (25.0)
• Neither easy nor difficult	6 (13.6)
What about this program made it easy to participate? Select all that apply	
• Free blood pressure machine	33 (75)
• Ability to monitor my blood pressure at home	34 (77.2)
• Text reminders to check my blood pressure	24 (54.5)
• Technical support	20 (45.5)
• Scheduled telemedicine visits to review my blood pressure readings	28 (63.6)
Participating in this program has:	
Lead to changes in how I manage my hypertension	
• Strongly agree	28 (63.6)
• Agree	11 (25.0)
• Neutral	4 (9.1)
• Disagree	1 (2.3)
• Strongly disagree	0 (0)
Helped me to better manage my hypertension	
• Strongly agree	35 (79.5)
• Agree	7 (15.9)
• Neutral	1 (2.3)
• Disagree	1 (2.3)
• Strongly disagree	0 (0)

Responses have been given as *n* (%).

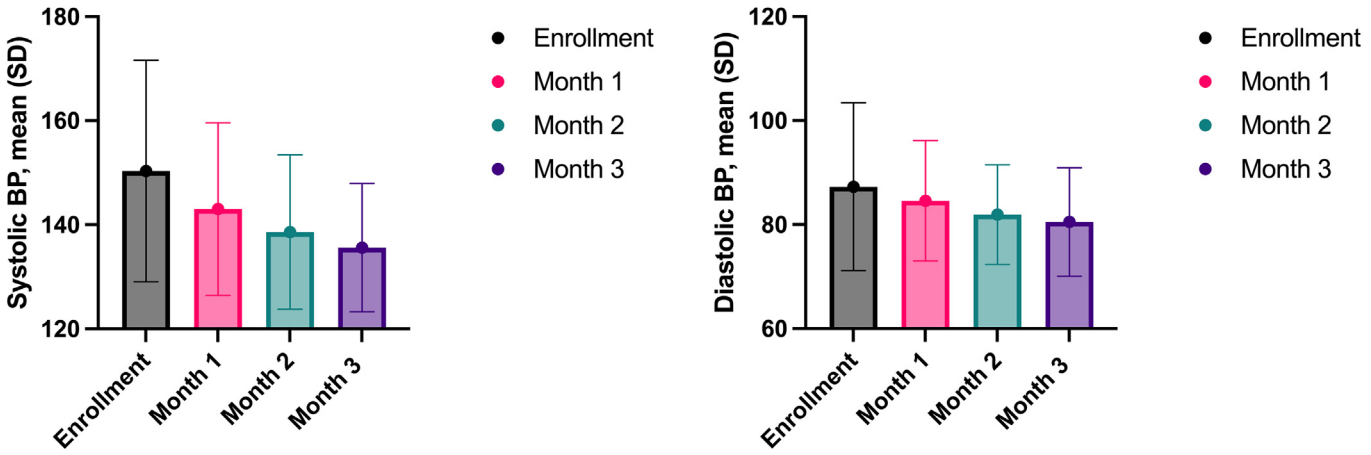

Figure 3. Change in systolic and diastolic blood pressure over 3 months.

Adverse Events

No serious adverse events were observed with remote adjustment of antihypertensive medications. Six patients (6.9%) experienced a transient episode of acute kidney injury. Seven patients (8%) experienced mild hypokalemia, and 8 patients (9.2%) experienced mild to moderate hyperkalemia (Table 2). All episodes resolved with dietary counseling and/or adjustment of diuretic. No patients required emergency room or hospitalization because of acute kidney injury or electrolyte disorders; however, 2 patients had hypertension-related hospitalizations. Four patients (4.6%) had alarms for asymptomatic hypotension. Two patients required reduction in antihypertensive medications.

DISCUSSION

We investigated the feasibility and short-term effectiveness of an interdisciplinary RPM hypertension program in a high-risk CKD population in a real-world setting. The majority of patients who were invited to participate agreed to enroll and were retained in the program for at least 3 months or until they reached their BP goal. Enrollment in the program was associated with a clinically significant reduction in systolic BP of 15 mm Hg and diastolic BP of 6.7 mm Hg by 3 months. By 6 months, 49.4% of those who were retained in the program achieved the American College of Cardiology and the American Heart Association guideline recommended BP target of $<$ 130/80 mm Hg for patients with CKD. Because hypertension is highly prevalent and difficult to control in patients with CKD, these significant findings highlight the ability of an interdisciplinary RPM care model to improve BP control among high-risk patients with CKD.

Overall, patients enrolled in our program were satisfied with the RPM approach to manage BP and thought the frequency and setting of televisits were appropriate for hypertension management. Hypertension management traditionally occurs in the office. However, frequent office visits for uncontrolled hypertension are challenging and costly for patients. Moreover, it is difficult for nephrologists to see patients every month if BP is not at goal and may result in shifting focus away from other aspects of CKD care. Importantly, home BP measurements correlate more closely with cardiovascular events and related death, highlighting their prognostic importance.[28] Retention in the program at 3 months was 85%, which is consistent with other studies that have reported high adherence to telemedicine-based hypertension programs ranging from 48% to 90%.[16,29] Although we observed a small reduction in frequency of BP monitoring with increasing time in the program, most participants continued to measure their BP at least 50% of the days per month at 3 months. Most patients reported that they continued to check their BP at home several times per week after program disenrollment, indicating a potential legacy effect of sustained self-management. Future studies are needed to evaluate whether the effects of RPM are long-lasting on home BP monitoring and control.

Our program focused on adoption of hypertension guideline recommendations, including use of nonphysician teams, treatment algorithms, and integration of digital technology into clinical care. Large health systems have shown that standardized algorithms can improve BP control at the population level.[25,30] After implementing a standardized algorithm for BP medication titration, we observed an increase in usage of diuretics and calcium channel blockers, both first line

Table 3. Clinical management and outcomes of patients in the RPM program ($n = 87$)

Outcomes	BP, mean (SD)	Monthly BP change, mean (SD)	*P*-value for between group change
Systolic BP, mm Hg			
Enrollment	150.6 (21.3)	-	-
Month 1	144.5 (15.7)	–6.1 (13.9)	0.0001
Month 2	139.7 (13.0)	–4.8 (9.8)	< 0.0001
Month 3	135.6 (12.3)	–4.1 (10.1)	0.0003
Diastolic BP, mm Hg			
Enrollment	87.3 (16.1)	-	-
Month 1	85.3 (11.9)	–1.9 (17.0)	0.30
Month 2	82.6 (9.3)	–2.7 (7.6)	0.001
Month 3	80.5 (10.4)	–2.1 (5.1)	0.0003
BP <130/80 mm Hg, n (%)			
Month 3			31 (35.6)
Month 6			43 (49.4)
Number of antihypertensive medications, mean (SD)			
Enrollment			2.8 (1.3)
Month 3			3.2 (1.3)
Number of visits with nurse practitioner over 3 mo, median (IQR)			4 (2–7)
BP alarms, median (IQR)			
Month 1			0 (0, 1)
Month 2			0 (0, 1)
Month 3			0 (0, 0)
Number of days per month BP measured, median (IQR)			
Month 1			23 (13–28)
Month 2			20 (9–26)
Month 3			16 (5–24)
Number of times per month BP measured, median (IQR)			
Month 1			30 (17–47)
Month 2			26 (11–37)
Month 3			21 (5–31)
Adverse events, *n* (%)			
Acute kidney injury			6 (6.9)
Hypokalemia (range: 3.0–3.4 mEq/l)			7 (8.0)
Hyperkalemia (range: 5.3–5.9 mEq/l)			8 (9.2)
Hyponatremia (range: 128–134 mEq/l)			6 (6.9)
Hypotension			4 (4.6)
Emergency room visit for hypertension			2 (2.0)
Hypertension-related hospitalization			2 (2.0)
Deaths			0 (0.0)

BP, blood pressure; IQR, interquartile range; RPM, remote patient monitoring.

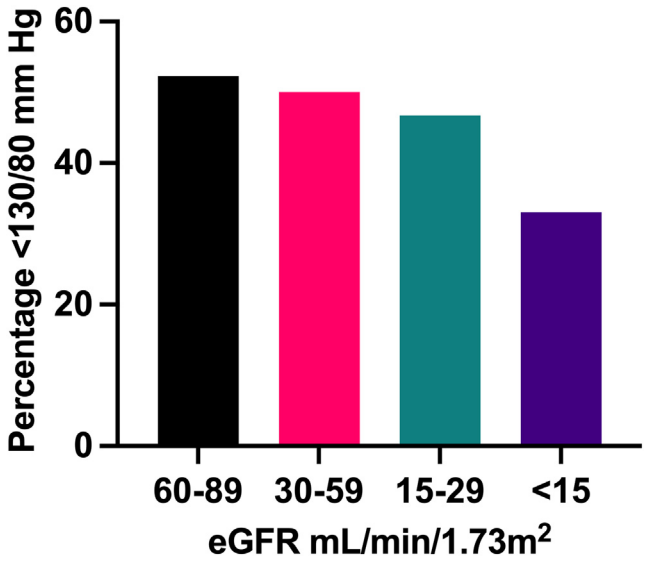

Figure 4. Percentage (%) that achieved target blood pressure (<130/80 mm Hg) in each KDIGO stage. eGFR, estimated glomerular filtration rate; KDIGO, Kidney Disease Improving Global Outcomes.

medication classes for hypertension. Notably, there was only a modest increase in the number of antihypertensive medications. This is consistent with a meta-analysis of 23 randomized controlled trials which reported a similar increase in medication number with remote BP monitoring compared with usual care.[31] One potential explanation for this finding is that patients were changed to more effective antihypertensive medications. Other unmeasured factors that likely contributed to improved BP include increased medication adherence and lifestyle changes resulting from interactions and education by an NP.

Observational studies and clinical trials have shown that remote BP monitoring when combined with team-based care providing education and medication titration results in greater BP reduction compared with usual care.[25,32] However, data in patients with CKD are limited. Previous studies in the Veterans Affairs health system found no advantage of telemedicine for hypertension management in CKD compared with usual care.[29,33] However, a meta-analysis of 7 observational studies and randomized trials ranging from 3 to 12 months in length that included 130 nondialysis patients with CKD demonstrated a systolic BP reduction of 8.8 mm Hg using remote BP monitoring with management.[34] A recent observational study that implemented a virtual care model consisting of a pharmacist and nephrologist resulted in a reduction in systolic BP of approximately 16 mm Hg over 6 months in 55 veterans, who were predominantly White men, with moderate CKD.[35] We observed similar BP reduction in our study, which had equal representation of men and women and was predominantly Black and Hispanic. This suggests that an interdisciplinary RPM care model is generalizable to diverse populations and may improve equity in BP control.

The Surgeon General's Call to Action to Control Hypertension highlighted disparities in hypertension among minority groups because of social and economic inequalities.[36] A considerable strength of our study was its real-world setting and focus on racial and ethnic minority patients with CKD, a population known to have poor health outcomes. We demonstrated that an interdisciplinary RPM hypertension program can be successfully implemented in an underserved CKD population. Our findings are consistent with studies of non-CKD minority patients in low-income settings. The telephone was the most frequent mode of

communication, which was acceptable to most patients. The automated transmission of BP readings via a cellular-enabled BP device helped our population from an equity perspective because it did not require patients to have wireless internet or smartphones for their BP data to be transmitted to our team. Finally, the use of nonphysician teams to help manage hypertension also allowed nephrologists to focus office visits on other important aspects of CKD care.

Our study has several important limitations. Although participation in our RPM program was high and similar to other studies, we recognize that this was a real-world setting in which there could be selection bias in offering the program to patients more likely to participate and adhere to the intervention. Although observational studies and clinical trials have shown that remote hypertension management using a team-based approach results in better BP control compared with usual care, we did not compare the effectiveness of our program with usual care. We were also unable to differentiate which component of the program was the most effective in improving BP. However, previous studies have indicated that self-monitoring of BP alone is not effective in improving BP.[14] We surmise that combined behavioral changes, improved adherence, and medication intensification all contributed to BP reduction. Though we observed a decrease in the proportion with BP control with worsening stage of CKD, the proportion of patients with CKD stage G4 that achieved BP control was similar to milder CKD, indicating that an interdisciplinary RPM program can improve BP in more advanced CKD. However, because of the small sample size, we could not formally test this hypothesis. Lastly, we did not perform a cost analysis to determine if our program is more cost-effective than usual care. However, analyses from large trials have projected lower costs associated with RPM compared with usual care through reduction in cardiovascular events and related death.[37,38]

CONCLUSION

Implementation of an interdisciplinary RPM hypertension program in high-risk CKD patients with uncontrolled hypertension is feasible and results in improved BP control. This care model has the potential to improve BP control among high-risk patients with CKD. Future studies that evaluate sustainability of BP reduction using this approach compared with usual care are needed.

DISCLOSURE

All the authors declared no competing interests.

ACKNOWLEDGMENTS

We would like to acknowledge our care management organization and institution's support and commitment to increasing health equity among our patient population.

Funding

MCF was supported by the NIH/National Center for Advancing Translational Sciences (NCATS) Einstein-Montefiore CTSA Grant #UL1TR001073. TSJ was supported by K23 grant from the NIH/NIDDK (K23 DK124644). The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the funding agencies.

SUPPLEMENTARY MATERIAL

Supplementary File (PDF)

Supplementary Methods. Patient feasibility survey questions.

Figure S1. Algorithm for initial medication titration.

Figure S2. Medication algorithm for resistant hypertension.

Figure S3. Safety parameters after starting or intensifying a diuretic.

Figure S4. Safety parameters after starting or intensifying an ACEi, ARB or MRA.

Table S1. Antihypertension medication dosing.

Table S2. Combination pill suggestions.

Table S3. Equivalent potencies of common hypertension medications.

Table S4. Antihypertensive medication class.

Table S5. Blood pressure change from enrollment to 3 months in all enrolled participants.

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