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ORIGINAL RESEARCH

Improvement in Blood Pressure Control in Safety Net Clinics Receiving 2 Versions of a Scalable Quality Improvement Intervention: BP MAP A Pragmatic Cluster Randomized Trial

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BACKGROUND: Uncontrolled blood pressure (BP) remains a leading cause of death in the United States. The American Medical Association developed a quality improvement program to improve BP control, but it is unclear how to efficiently implement this program at scale across multiple health systems.

METHODS AND RESULTS: We conducted BP MAP (Blood Pressure Measure Accurately, Act Rapidly, and Partner With Patients), a comparative effectiveness trial with clinic-level randomization to compare 2 scalable versions of the quality improvement program: Full Support (with support from quality improvement expert) and Self-Guided (using only online materials). Outcomes were clinic-level BP control (<140/90 mm Hg) and other BP-related process metrics calculated using electronic health record data. Difference-in-differences were used to compare changes in outcomes from baseline to 6 months, between intervention arms, and to a nonrandomized Usual Care arm composed of 18 health systems. A total of 24 safety-net clinics in 9 different health systems underwent randomization and then simultaneous implementation. BP control increased from 56.7% to 59.1% in the Full Support arm, and 62.0% to 63.1% in the Self-Guided arm, whereas BP control dropped slightly from 61.3% to 60.9% in the Usual Care arm. The between-group differences-in-differences were not statistically significant (Full Support versus Self-Guided=+1.2% [95% CI, −3.2% to 5.6%], *P*=0.59; Full Support versus Usual Care=+3.2% [−0.5% to 6.9%], *P*=0.09; Self-Guided versus Usual Care=+2.0% [−0.4% to 4.5%], *P*=0.10).

CONCLUSIONS: In this randomized trial, 2 methods of implementing a quality improvement intervention in 24 safety net clinics led to modest improvements in BP control that were not statistically significant.

REGISTRATION: URL: https://www.clinicaltrials.gov; Unique identifier: NCT03818659.

Key Words: blood pressure ■ comparative effectiveness ■ hypertension ■ quality improvement ■ quasi-experimental design

Uncontrolled blood pressure (BP) is the leading preventable cause of death in the United States after smoking, causing nearly 40000060 deaths per year.[1,2] Although effective medications are available to control BP, multiple rounds of medication adjustment and intensification are typically required, and BP control is often not achieved.[3–7]

To disseminate best practices for improving BP control in the US population, the American Medical Association (AMA) developed a framework and quality

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CLINICAL PERSPECTIVE

What Is New?

- Dissemination of a quality improvement intervention with and without practice facilitation in 24 safety net clinics led to modest improvements in blood pressure control that were not statistically significant.
- Confirmation and documentation of elevated blood pressure through repeated clinic measurements did not reduce therapeutic inertia.

What Are the Clinical Implications?

- Quality improvement efforts to improve blood pressure control should directly target missed opportunities to escalate medication treatment for elevated blood pressure.
- Future interventions should consider employing more hands-on strategies—such as clinical decision support and automated scheduling—to automate protocolized treatment intensification and frequent follow-up.

Nonstandard Abbreviations and Acronyms

AMA	American Medical Association
MAP	Measure Accurately, Act Rapidly, and Partner With Patients
PCORnet	Patient-Centered Clinical Research Network
REACHNet	Research Action for Health Network

improvement program: the BP "Measure Accurately, Act Rapidly, and Partner with Patients" (BP MAP) program. The initiative includes a set of tools, resources, and detailed plans to support clinics interested in implementing the MAP framework as a structured intervention program and process measures aligned with each of the MAP program domains. In an uncontrolled quasiexperimental study, implementation of this program at 16 clinics within a single health system led to significant improvements in BP control,[8] but this program included significant training and support from AMA quality improvement specialists that may not be easily replicable at scale. To facilitate rapid adoption across multiple health systems, the AMA modified the program with enhanced interactive online toolkits that a clinic or health system can use for quality improvement training, implementation, and performance monitoring. It is unclear whether an abbreviated, scalable version of the BP MAP program, using the online toolkits, would be similarly effective and how much external support clinics would be needed to successfully improve BP control.

We used the Patient-Centered Clinical Research Network (PCORnet) BP Control Laboratory[9] to test effectiveness of 2 modified, scalable versions of the BP MAP program. The PCORnet Blood Pressure Control Laboratory uses electronic health record (EHR) data from health systems participating in the National PCORnet to support BP control surveillance and efficient pragmatic trials of interventions designed to improve BP control at scale.[9] In collaboration with the AMA, we used the PCORnet infrastructure and the BP MAP framework to conduct BP MAP, a pragmatic, cluster-randomized comparative effectiveness trial in 24 safety net clinics across 9 health systems and 4 states. The primary goal of BP MAP was to compare the effectiveness of 2 versions of the program, one with and one without dedicated practice facilitation, at improving BP control among patients with hypertension.

METHODS

Data-use agreements with contributing sites prohibit sharing of BP MAP data with external investigators. However, the BP Control Laboratory accepts proposals for collaborative analysis and publications. Proposals are subject to review by the BP Control Laboratory Steering Committee for scientific value, avoidance of overlap with previously approved proposals, compliance with our publication policies, and availability of resources for analysis of the data. Interested investigators may contact the corresponding author with inquiries.

Study Design

We conducted a pragmatic, cluster-randomized, comparative effectiveness trial designed to compare the effectiveness of the BP MAP program with dedicated practice facilitation ("Full Support") versus a version of the program without practice facilitation ("Self-Guided"), at improving clinic-level BP control at 6 months. We also analyzed each intervention arm compared with health systems that were not receiving any AMA-led intervention ("Usual Care"). This planned comparison with a nonrandomized Usual Care arm is a robust quasiexperimental design widely used in real-world implementation science because randomization to a control group is often not acceptable or desirable to stakeholders, as was the case in this study.[10–13]

Quality Improvement Setting and Requirements for Clinic Participation in BP MAP

We enrolled safety net clinics from 2 clinical research networks participating in the PCORnet BP Control Lab - Research Action for Health Network (REACHNet)[14,15] and Accelerating Data Value Across a National Community

Health Center Network[16] —to test whether the BP MAP program would scale effectively in multiple community health centers and Federally Qualified Health Centers. Clinics were recruited from health systems to be study sites by REACHnet and Oregon Community Health Information Network,[17–19] the lead contributing partner for Accelerating Data Value Across a National Community Health Center Network, if health system leadership indicated interest in implementing the MAP intervention. Clinics were excluded if they (1) had implemented any quality improvement component from the BP MAP improvement program as part of previous initiatives, or (2) were currently involved in an ongoing clinical trial or grant-funded project related to high BP or hypertension. Once included, clinics in the Full Support arm were required to designate (1) a Site Champion who works at the clinic to take primary responsibility for implementing the BP MAP intervention; (2) a Physician Champion who works at the clinic to advocate actively for the BP MAP intervention; and (3) a regional/network-level Practice Change Facilitator willing to attend a 1-day training and help guide implementation of the BP MAP intervention. From REACHnet, a total of 14 clinics from 2 health systems in Louisiana and from Oregon Community Health Information Network, 10 clinics from 7 health systems in Oregon, California, and Washington met criteria and were included in the study. Clinics were compensated for their participation in the research. BP MAP was approved by the institutional review board of each participating health system. As part of our data use agreement with the PCORnet BP Control Lab, participating clinics agreed to provide aggregated data only; patient-level data were not available. Informed consent of patients was not required for this study. The study protocol was registered with clinicaltrials.gov (trial number NCT03818659).

Usual Care Control Arm

The BP Control Lab conducts ongoing surveillance for BP control and related health care metrics, calculated quarterly, in 27 health system-based PCORnet datamarts across the United States participating in BP Track, the PCORnet Blood Pressure Control Laboratory's surveillance program.[9] A Usual Care nonrandomized control group was defined for BP MAP, using all health systems participating in BP Track with good quality BP metrics data from July 1, 2018 to December 31, 2019 (concurrent with the BP MAP trial) except for those associated with REACHnet and Oregon Community Health Information Network (see Table S1 for list of included health systems).

Full Support and Self-Guided Intervention Arms

The BP MAP program[8] is designed to help clinics adopt standard processes to obtain accurate clinic BP measurements (*Measure accurately*), rapidly escalate medication therapy for uncontrolled hypertension through implementation of an evidence-based algorithmic treatment protocol and frequent follow-up encounters (*Act rapidly*), and engage patients to encourage self-measured BP monitoring, medication adherence, and lifestyle modifications (*Partner with patients*).

To implement BP MAP efficiently at scale across multiple health systems, the AMA created a new "Digital Guide" web portal with a set of tools, resources, and plans designed for self-service access by clinic leadership and staff. The Digital Guide includes 5 online training modules: (1) an overview of the program, (2) a module for each of the M, A, and P domains, and (3) a module on self-measured BP. The modules include practical strategies, structural changes in clinic operations to facilitate accurate BP measurements and best quality improvement practices for adoption of standardized treatment algorithms, and validated communication strategies for engaging patients in self-management. BP MAP is a 6-month program designed for each domain to be implemented sequentially over approximately 2 months, with training on the corresponding modules to coincide with that sequence. See Figure S1 and Tables S2 and S3 for description and sample of tools available in the Digital Guide.

To facilitate timely performance tracking and identify specific gaps in implementation of the domains of the program, monthly *reports* were distributed to site champions by email. Reports were composed of simple noninteractive tables of clinic-level performance metrics derived from EHR data and included our primary and secondary outcomes (described later). Real-time access to 4 selected performance metrics (BP control, confirmatory BP measurement, medication intensification, and average change in systolic BP [SBP] after medication intensification), linked interactively to patient listings and individual clinicians, was also made available to all sites in the form of a *performance dashboard* embedded into their EHR or in the clinic's population management platform.

Clinics in both intervention arms received access to the Digital Guide, monthly reports, and performance dashboards. In the Full Support arm, a Practice Change Facilitator was designated at the system/network level (across multiple clinics) to actively facilitate implementation of the program. The Practice Change Facilitators, who were trained and supported by an AMA improvement specialist, trained staff in the Full Support arm clinics on the intervention. Clinics randomized to the Self-Guided arm did not receive support from a Practice Change Facilitator.

Before randomization, the study team hosted an introductory webinar with clinic staff to provide an overview of the intervention, describe responsibilities

and expectations, explain the need to identify specific individuals who would serve in each required role, and confirm the clinic's commitment to the program. After entrance criteria were confirmed, we used a random number generator to randomize 12 clinics to the Full Support arm and 12 clinics to the Self-Guided arm. Randomization was stratified and balanced at the level of clinical research networks and multisite health systems within each clinical research network, such that for each network and multisite health system, half of their sites were randomized to one intervention arm versus the other. After randomization, the intervention was launched sequentially at all 24 clinics. At Self-Guided clinics, Site Champions were simply told to initiate the program and given access to the Digital Guide. Full Support clinics additionally received an onsite "Kickoff" visit by AMA quality improvement experts that included a site assessment followed by a 60-minute educational session for the providers and care teams. All 24 sites launched quality improvement efforts (including all 12 Kickoff visits) within 2 months.

For clinics randomized to the Full Support arm, the Practice Change Facilitators (1) performed a baseline assessment of current workflows and assessed each domain of MAP for the purpose of identifying gaps and planning for specific incremental modifications tailored to address specific clinic needs, (2) performed periodic check-ins with the AMA Improvement Specialist for coaching support and to monitor use of the intervention assessment tools and checklists, and (3) supported use of performance dashboards and monthly reports by clinic staff. Clinics randomized to the Self-Guided arm received no support from a Practice Change Facilitator.

Outcomes

Outcomes for the study were BP control metrics, each calculated for a 1-year measurement period starting a year before the date of analysis. BP control metrics were analyzed at baseline and 6 months using EHR data queries defined and maintained by the PCORnet BP Control Lab.[9] To be included in analyses *patients had to be adults with hypertension*, defined according to National Quality Forum's BP Control Measure (NQF 0018) criteria,[20] as patients who (1) were age 18 to 85 years on the date of analysis, (2) had at least 1 outpatient encounter with a diagnosis of hypertension (according to *International Classification of Diseases, Ninth and Tenth Revision* [*ICD-9, ICD-10*] codes) during the first 6 months of the measurement year (ending on the date of analysis), (3) had no diagnosis or evidence of end-stage renal disease on or before the end of the measurement year, (4) had no pregnancy during the measurement year, and (5) had no admissions to an inpatient setting during the measurement year.

Our *primary outcome* was change in clinic-level BP control from baseline to follow-up at 6 months after the start of the intervention. We defined BP control for a 1-year lookback period, according to the National Quality Forum's Controlling High Blood Pressure Measure definition (NQF 0018[20]), as the percentage of eligible patients (defined previously) with SBP <140 mm Hg and diastolic BP <90 mm Hg using the lowest measures of SBP and diastolic BP recorded from the most recent ambulatory clinical encounter. BP control was calculated identically at baseline (for a 1-year measurement period ending the month before the Kickoff), and at the 6-month time point (for the 1-year measurement period ending at least 6 months after initiation of the intervention). Because initiation of the intervention occurred generally during the middle of a calendar month, the 2 queries were 7 months apart (Figure S2).

Secondary outcomes included 8 additional EHR-derived clinic-level process metrics relevant to BP control that are defined and maintained by the BP Control Laboratory.[9] These metrics included alternative measures of BP control and improvement, as well as process and proxy measures aligned to the domains of the BP MAP program, including indicators of BP measurement quality and accuracy, medication intensification when BP is uncontrolled, medication prescribing quality, average SBP reduction after medication intensification, and repeat visit within 4 weeks after a visit with uncontrolled hypertension. Each metric was calculated on a monthly basis, overall and within subgroups defined by age, sex, and race or ethnicity. See Table S4 for detailed definitions and rationale for the clinic-level metrics. Overall metric results for each clinic were provided in monthly reports to Site Champions, as described previously. Each month, and for each participating clinic, the 10 BP control metrics were calculated by running Statistical Analysis System (SAS, Inc., Cary, NC) queries against EHR data maintained in the PCORnet Common Data Model at each health system.

Other Measurements

The BP Control Lab collects clinic-level information about patient characteristics, including demographic characteristics (% patients within different age, sex, and race or ethnicity groups) and comorbidities (diabetes, heart failure, depression, and chronic obstructive pulmonary disease) for all participating clinics and health systems. For this project, we also asked clinic administrators at the 24 intervention clinics before randomization to report their clinic's workforce composition (proportion of nurse practitioners, physician assistants, physicians, and physician specialty—internal versus family medicine), size and staffing

(total number of patients, nurses, and medical assistants), and level of access (availability of same-day appointments, mean time to third next available appointment[21]).

Statistical Analysis

We compared baseline characteristics between the Full Support and Self-Guided intervention arms and then between the Usual Care health systems and the 2 intervention arms combined. *P* values were calculated using weighted mean ANOVA accounting for the clinic-level randomization scheme.

For our primary analyses, we used an unadjusted difference-in-differences analytic approach to test our hypotheses. We used clinic-level metrics (eg, % BP control) at baseline for each clinic before intervention starts (t0) and at 6 months (t6), and calculated the clinic-level pre-post difference in the metric (t6–t0), and then compared the pre-post differences by arm using a weighted *t*-test of the null hypothesis that the difference-in-differences is zero. We also calculated 95% CIs for the mean pre-post difference in each treatment group and the difference-in-differences. Observations were weighted by the inverse of the site-specific variances of the change scores, which were approximated using the number of observations (eg, number of adult patients with hypertension) at each clinic time point, and the level of the metric, and the average correlation of the pre- and post-metrics across clinics. Weights were normalized to the number of clusters analyzed in each contrast. We performed 3 prespecified pairwise comparisons (Full Support versus Self-Guided, Full Support versus Usual Care, and Self-Guided versus Usual Care) and set our critical *P* value thresholds at *P*=0.04 for the Full Support versus Self-Guided comparison and *P*=0.005 for the other 2 comparisons in order to maintain an overall type 1 error rate of 5%. To assess for heterogeneity of effect, we performed 4 prespecified subgroup-specific analyses, limiting metric calculations by clinic to subgroups based on age, sex, race or ethnicity, and enrolling network.

Although our difference-in-differences approach provides protection against confounding, we also conducted a prespecified sensitivity analysis using multivariable linear regression to compare clinic-level pre-post differences in our primary and secondary outcomes adjusted for age, sex, and race or ethnicity, all of which are potentially strong predictors of BP control and thus potential confounders in our analysis if imbalanced between arms.

Halfway through our trial, 6 clinics (3 in each intervention arm) underwent unanticipated adoption of a new EHR system and lost access to the monthly reports and dashboards. In a post hoc sensitivity analysis, we excluded these clinics and repeated our primary (unadjusted) analysis comparing pre-post differences in BP control between the 2 intervention arms and each intervention with Usual Care.

All statistical analyses were performed using Stata 16 (Stata Corp., College Station, TX).

RESULTS

A total of 24 safety net clinics from 9 health systems in 4 states were enrolled in the study (Figure 1). The clinics participating in the trial were small (≤5 physicians each) and served mostly patients with public insurance (<20% of patients had private insurance). Clinics randomized to Full Support and Self-Guided arms were similar with respect to median numbers of patients with hypertension, patient demographics (age, sex, and race), and prevalence of comorbid conditions such as diabetes, heart failure, depression, and chronic obstructive pulmonary disease, and they had similar workforce composition, staffing, and level of access to timely appointments at baseline[22] (Table 1). Patients at Usual Care health systems were older, more likely male, and more predominantly White.

Clinic-level BP control improved on average from 56.7% to 59.1% in Full Support clinics and from 62.0% to 63.1% in Self-Guided clinics, whereas BP control fell slightly on average in Usual Care health systems from 61.3% to 60.9%. The between-group differences in these changes were not statistically significant according to our prespecified weighted-average comparison methods (Figure 2, Table 2). Difference-in differences were Full Support versus Self-Guided=+1.2% (95% CI, −3.2% to −5.6%, *P*=0.59); Full Support versus Usual Care=+3.2% (95% CI, −0.5% to 6.9%, *P*=0.09); and Self-Guided versus Usual Care=+2.0% (95% CI, −0.4% to 4.5%, *P*=0.10). We also found no clear subgroup interactions, with intervention effects on BP control not consistently or significantly differing by sex, age group, race, or network (Figure 3).In contrast to our primary outcome metric (clinic-level BP control), we saw large improvements in documentation of a confirmatory repeated BP measurement, which increased from 45.2% to 64.8% in Full Support clinics and 49.5% to 64.0% in Self-Guided clinics, but no improvement in the Usual Care health systems (difference-in-differences: Full Support versus Usual Care=+19.7% [95% CI, 6.8% to −32.6%], *P*=0.004; Self-Guided versus Usual Care=+11.5% [95% CI, 2.0% to −21.0%], *P*=0.019; Tables 2 and 3). We also saw a significant improvement in average SBP reduction after medication intensification in Full Support clinics from 15.6 to 16.9 mm Hg that was greater than Usual Care (difference-in-differences=+3.4 mm Hg [95% CI, 2.0 mm Hg to −4.9 mm Hg], *P*<0.001). No significant improvements occurred in any other BP-related process metrics, and there were no significant differences in

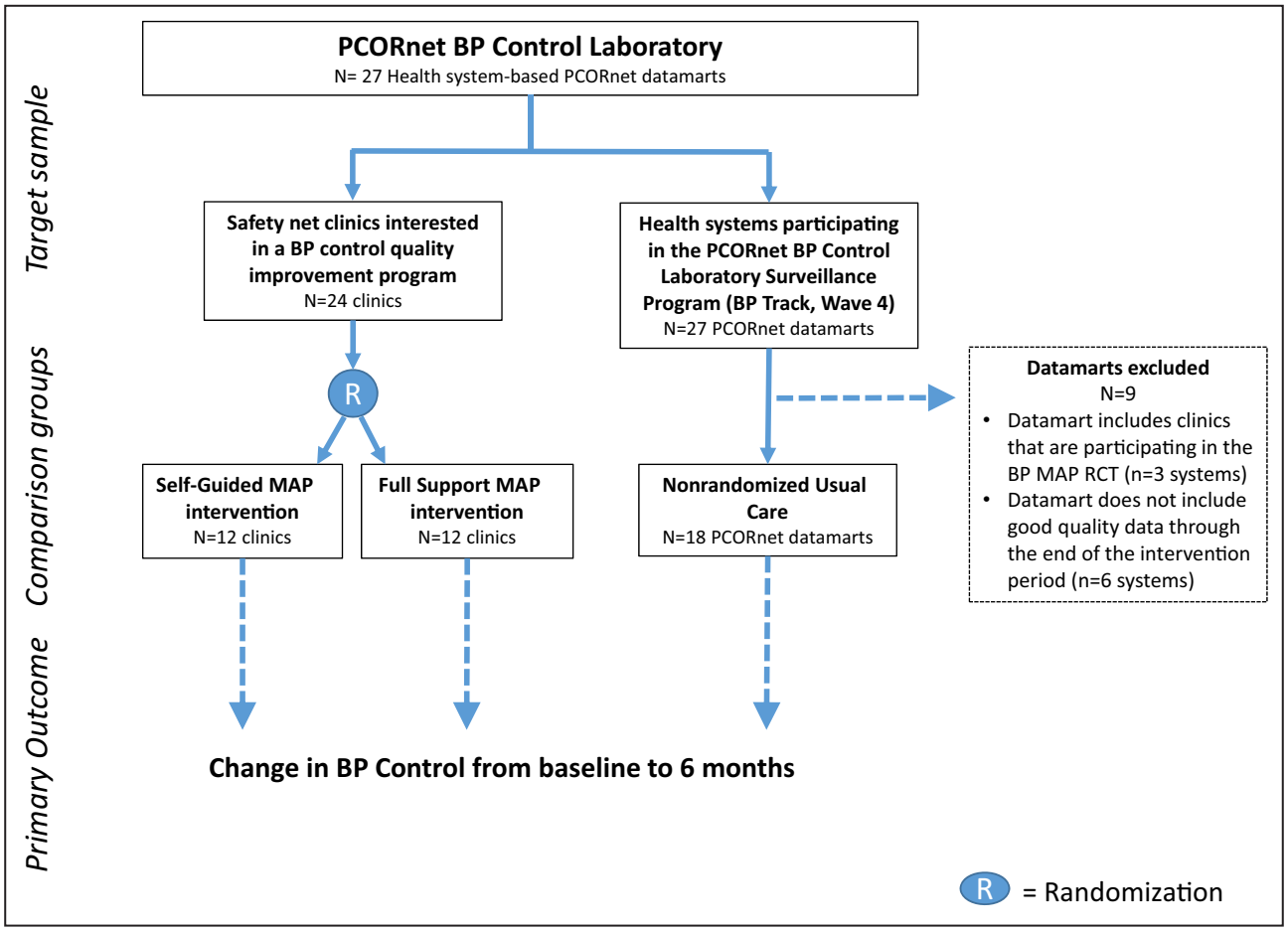

Figure 1. Consort diagram and study design.
BP indicates blood pressure; MAP, Measure Accurately, Act Rapidly, and Partner with Patients; PCORnet, Patient-Centered Clinical Research Network; and RCT, randomized controlled trial.

any of the secondary outcomes between Full Support and Self-Guided clinics.

With adjustment for age, sex, and race (a prespecified secondary analysis), difference-in-difference contrasts in clinic-level BP control were statistically significant for both Full Support versus Usual Care (+3.1% [95% CI, 1.3% to −4.9%, $P<0.001$]) and Self-Guided versus Usual Care (+2.1% [95% CI, 0.85% to −3.3%, $P=0.002$]) but not for the Full Support versus Self-Guided contrast. Additional adjusted results are presented in Table S5.

In a post hoc sensitivity analysis excluding clinics that changed their EHR vendor during the study period, both the Full Support and Self-Guided interventions led to significant improvements in BP Control compared with Usual Care with difference-in-differences of +5.1 (95% CI, 0.7% to −9.5%, $P=0.024$) and +3.1 (95% CI, 0.4% to −5.9%, $P=0.026$). Difference-in-differences between Full Support and Self-Guided interventions were not significant (+2.0 [95% CI, −3.1% to 7.1%], $P=0.43$). Full results are provided in Table S6.

DISCUSSION

In this pragmatic cluster-randomized trial conducted within the PCORnet BP Control Lab, we implemented the BP MAP quality improvement program designed to improve clinic-level BP control simultaneously in 24 safety net clinics with 2 different methods—Full Support and Self-Guided (randomly assigned)—and compared their effectiveness against each other and a nonrandomized concurrent Usual Care control using standard EHR-derived BP control metrics. In contrast to Usual Care, clinics in both intervention groups achieved substantial gains in some BP-related quality metrics, most notably in documentation of confirmatory repeated BP measurement. Although we observed small increases in the proportion of patients with BP control in the intervention clinics, these increases were not statistically significant and were not statistically different between Full Support and Self-Guided arms or in contrast to Usual Care.

Despite efforts to engage physician champions in the Full Support clinics to promote adoption and

Table 1. Baseline Characteristics of Patients With Hypertension and Clinic Characteristics Across the Intervention Arms

	Randomized intervention arms			Nonrandomized Usual Care arm N=18 health system-based Patient-Centered Clinical Research Network datamarts	*P* value†
	Full-support clinics N=12 clinics	Self-Guided clinics N=12 clinics	*P* value*		
Baseline characteristics of patients with hypertension based on electronic health record data					
Average total number of patients with hypertension, median (IQR)	517 (299–1049)	1040 (630–1623)	0.1659	53 266 (26200–74 379)	<0.0001
Age, y, mean (weighted SD)	57.1 (2.49)	57.1 (2.61)	0.9386	63.47 (1.76)	0.0704
Age groups, % (weighted SD)			1.00		<0.001
18–44 y	16.0 (4.91)	16.1 (5.33)		9.3 (2.21)	
45–64 y	56.5 (4.50)	56.5 (6.07)		38.1 (4.58)	
65+ y	27.5 (8.03)	27.4 (8.38)		52.6 (6.14)	
Female sex, % (weighted SD)	57.2 (5.80)	60.7 (5.75)	0.21	51.4 (3.08)	<0.001
Race or ethnicity, % (weighted SD)			0.22		<0.001
White	50.3(33.8)	29.8 (27.01)		79.2 (15.56)	
Latinx	10.3 (5.9)	26.3 (28.3)		3.1 (2.01)	
Black	34.9 (33.8)	36.8 (34.6)		13.4 (15.3)	
Asian	1.6 (2.34)	3.8 (5.69)		1.7 (0.67)	
Other/multiple/ missing	3.0 (2.29)	3.2 (2.69)		2.5 (0.95)	
Comorbidities, % (weighted SD)					
Diabetes	29.9 (3.43)	33.8 (9.89)	0.2673	26.7 (2.74)	0.4006
Heart failure	2.9 (1.51)	2.6 (1.36)	0.5381	6.8 (1.30)	0.1328
Depression	17.0 (9.47)	18.2 (16.4)	0.8548	14.5 (5.80)	0.9386
Chronic obstrucitve pulmonary disease	6.6 (4.18)	4.4 (02.43)	0.1458	5.7 (1.51)	0.8908
Baseline data on clinic characteristics reported by clinic administrators				NR	NR
Total number of patients, median (IQR)	2771 (1562–4476)	4000.5 (2137.5–5547)	0.3262		
Payer mix, %, median (IQR)					
Proportions of patients primarily covered by Medicare	7.71 (5.92–17.03)	6.40 (4.45–10.75)	0.3556		
Proportions of patients primarily covered by Medicaid	43.24 (34.15–61.65)	51.65 (33.75–67.58)	0.6861		
Proportions of patients primarily covered by Medicare and Medicaid	5.12 (3.45–9.00)	6.48 (2.84–11.16)	0.8065		
Proportions of patients primarily covered by private payer	13.70 (7.70–18.75)	8.97 (6.02–17.62)	0.3865		
Proportions of patients primarily covered by other payers	10.45 (1.20–15.78)	11.05 (0.68–17.56)	0.9538		

(*Continued*)

Table 1. Continued

	Randomized intervention arms			Nonrandomized Usual Care arm N=18 health system-based Patient-Centered Clinical Research Network datamarts	*P* value†
	Full-support clinics N=12 clinics	Self-Guided clinics N=12 clinics	*P* value*		
Clinics' workforce composition (full-time equivalent), median IQR)					
Nurse practitioners	1 (1–2.5)	3 (2–6)	0.0592		
Physicians	2 (1–4)	2 (2–5)	0.4090		
Medical Assistants	4.5 (3–7.5)	4.5 (3.5–8.5)	0.7936		
Clinics' level of accessibility to patients					
% Number of clinics with same-day appointments available	100	100			
Time (days) to third next available appointments[3], mean (SD)	1.85 (1.38)	3.52 (4.17)	0.0010		

Time to third-next-available appointment is widely used metric for appointment availability.[21,22] BP indicates blood pressure; IQR, interquartile range; and NR, not reported.

**P* value for comparisons between the 2 intervention arms.

†*P* value for comparisons between the Usual Care arm and the interventions arms combined.

implementation of an evidence-based treatment protocol aimed at reducing therapeutic inertia, neither intervention arm led to more rapid escalation of medication intensification nor improvements in the frequency of follow-up visits. Reducing therapeutic inertia (missed opportunities to escalate treatment when needed) is a necessary goal of any clinic-level intervention for improving BP control. Hence it is likely that the failure to induce providers to "Act Rapidly" through frequent follow-ups and escalation of medication treatment significantly contributed to the limited success in improving BP control. Because repeated BP measurements are typically lower than initial measurements, the interventions' success increasing the frequency of repeated measurements may have contributed to the small but statistically insignificant increases in BP control observed in the intervention arms.

Interestingly, the intervention groups' success in increasing confirmatory repeated BP measurements did not coincide with more frequent medication intensification for elevated BP. Part of the improvement in confirmatory repeated BP may have simply reflected better documentation of BP measurement, as intended. However, this

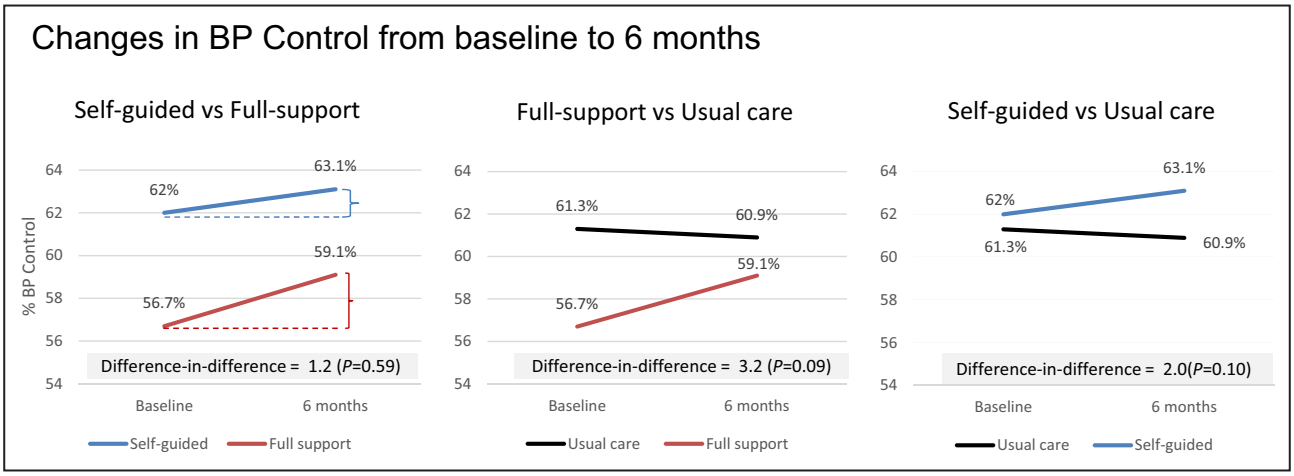

Figure 2. Difference-in-differences in blood pressure control.
This figure illustrates blood pressure control at baseline and 6 months for each intervention arm, and the differences in pre-post changes in % blood pressure control by arm (difference-in-differences) with *P* values for each contrast, including Full Support versus Self-Guided (**A**), Full Support versus Usual Care (**B**), and Self-Guided versus Usual Care (**C**). BP indicates blood pressure.

Table 2. Difference-in-Difference Analysis Comparing the Effects of Self-Guided and Full Support BP MAP Interventions on Improving Blood Pressure Performance Metrics From Baseline to 6 Months After Initiating the Intervention

BP performance metrics	Full Support clinics			Self-Guided clinics			Difference-in-difference[‡]	*P* value
	Baseline	At 6 months postintervention	Weighted difference[*]	Baseline	At 6 months postintervention	Weighted difference[†]		
Number of patients with hypertension	10 445	11 821	1376	13 163	14 454	1291	85	
Primary outcomes								
BP control, <140/90, % of patients	56.7 (54.3 to 59.1)	59.1 (56.0 to 62.2)	2.8 (−0.9 to 6.5)	62.0 (56.4 to 67.6)	63.1 (58.3 to 68.0)	1.6 (−0.8 to 4.0)	1.2 (−3.2 to 5.6)	0.59
Secondary outcomes								
Improvement in BP, % of patients	29.8 (28.0 to 31.6)	26.4 (20.3 to 32.5)	−3.4 (−10.3 to 3.5)	30.7 (27.9 to 33.6)	24.9 (20.5 to 29.4)	−5.4 (−8.2 to −2.5)	2.0 (−5.5 to 9.4)	0.60
Confirmatory repeated blood pressure measurement, % of visits	45.2 (26.7 to 63.6)	64.8 (54.0 to 75.5)	19.8 (6.9 to 32.7)	49.5 (32.8 to 66.2)	64.0 (54.4 to 73.6)	11.6 (2.1 to 21.1) *	8.2 (−7.9 to 24.2)	0.31
Medication intensification, % of visits	18.0 (13.5 to 22.4)	16.2 (14.0 to 18.3)	−1.6 (−6.1 to 3.0)	19.2 (14.4 to 24.0)	15.0 (13.7 to 16.2)	−3.4 (−8.2 to 1.2)	1.9 (−4.7 to 8.5)	0.56
Average systolic BP reduction after medication intensification, mm Hg	15.6 (12.4 to 18.8)	16.9 (14.8 to 19.1)	2.3 (0.9 to 3.7)	15.2 (12.8 to 17.5)	15.2 (11.7 to 18.8)	−1.6 (−5.6 to 2.4)	3.7 (−0.6 to 7.9)	0.07
Repeat visit within 4 weeks after a visit with elevated BP,[4] % of visits	28.2 (22.1 to 34.4)	26.7 (19.0 to 34.3)	−0.8 (−3.2 to 1.7)	24.8 (19.8 to 29.7)	23.6 (19.5 to 27.8)	−2.0 (−4.3 to 0.2)	1.3 (−2.0 to 4.6)	0.33
Use of fixed dose combination medications among patients taking 2 or more classes of medications, % of patients	36.6 (20.7 to 52.5)	38.9 (24.4 to 53.4)	1.6 (−1.4 to 4.7)	36.0 (23.6 to 48.3)	37.3 (25.9 to 48.8)	−0.1 (−1.8 to 1.7)	1.7 (−1.8 to 5.2)	0.26
Use of a calcium channel blocker or thiazide-type diuretic among Black patients on at least 1 medication, % of patients	86.1 (83.0 to 89.2)	85.1 (82.3 to 87.9)	−0.9 (−1.8 to 0.1)	84.8 (83.4 to 86.2)	84.6 (82.4 to 86.8)	−0.1 (−1.5 to 1.2)	−0.7 (−2.4 to 0.9)	0.39

Values are reported as mean (CI).BP indicates blood pressure; and MAP, Measure Accurately, Act Rapidly, and Partner With Patients. *P* <0.05.
*Weighted difference in performance metrics from baseline to 6 months post Full Support intervention.
†Weighted difference in performance metrics from baseline to 6 months post Self-Guided intervention.
‡Difference between difference[1] and difference[2].

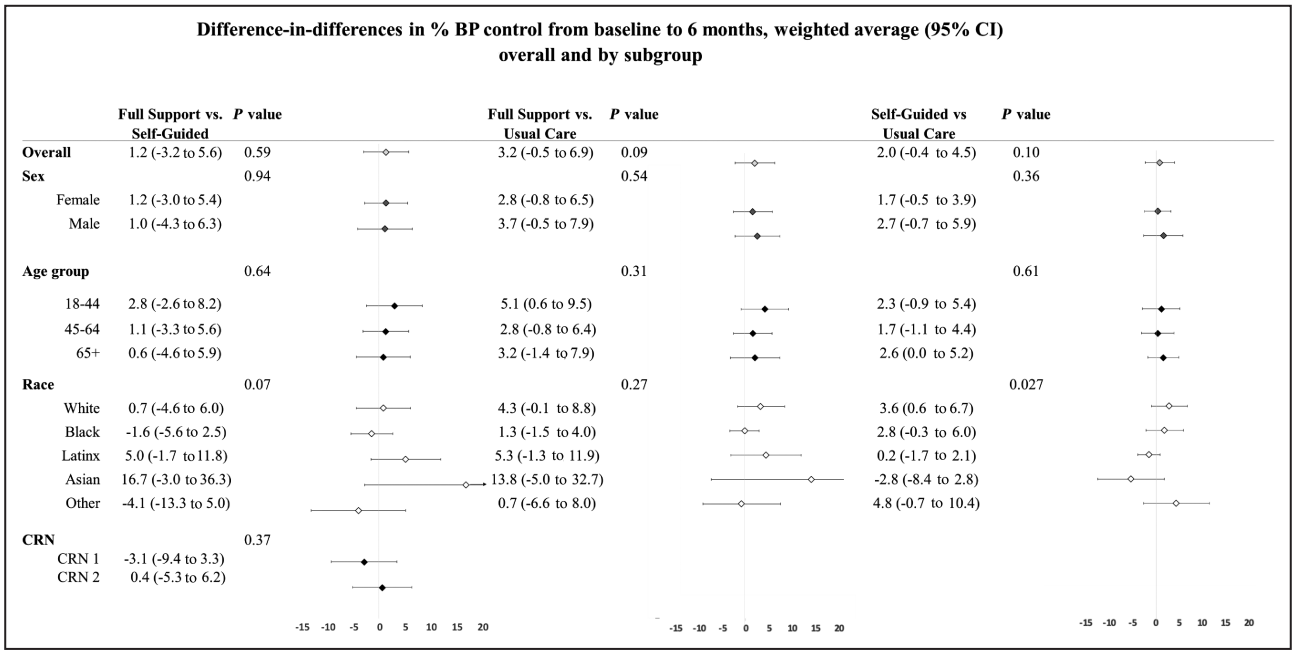

Figure 3. Forest plot of difference-in-differences in % blood pressure control by subgroup.
Mean (CI) change in % BP control from baseline to 6 months are presented overall, and stratified by sex, age, race, and research network. *P* values for heterogeneity across subgroups are presented. BP indicates blood pressure; and CRN, clinical research network.

finding suggests that even with documented confirmed elevated BP measurements, therapeutic inertia remains a major barrier to achieving BP control.

This study was designed to compare 2 different implementation strategies for scaling the abbreviated BP MAP program in community health centers and Federally Qualified Health Centers. The BP MAP program, which is intended for national dissemination, has previously shown success within single clinics or health systems that we could not replicate in a safety net clinic setting in this multisite, multihealth system trial. Previous pre-post pilot studies of the BP MAP program with staff training and support directly from AMA clinical team members showed 7% to 29% improvements in percentage of patients with BP control from baseline to 6 months with significant reductions in clinical inertia.[8,23] We could not replicate this improvement. The Full Support version of our intervention did include limited AMA support for the Practice Change Facilitator but not for clinic staff. This support appears not to have been sufficient for sustaining the high levels of engagement required to achieve large changes in health care processes and resulting increases in clinic-level BP control. Site Champions and Physician Champions were designated at each clinic; for some, their participation may have been driven by health system leadership's desire to participate in the study rather than a deep commitment to quality improvement among frontline stakeholders. In addition, clinical leaderships' many priorities may have precluded dedication of their time and resources to optimizing BP-related clinical workflows. Differences in our study design and analysis approach from prior evaluations of the BP MAP program may also partially explain differences in BP control improvement. We conducted a randomized controlled trial using serial cross-sectional analyses to measure clinic-level BP control and with difference-in-differences comparisons of parallel group controls, whereas previous analyses defined a cohort of patients with hypertension and analyzed pre-post changes in BP control within that cohort.

Some health systems have successfully implemented programs that have substantially increased BP control. For example, Kaiser Permanente successfully implemented a program to improve BP control,[24,25] at least 1 safety net health system has successfully adopted programs similar to Kaiser Permanente's and the BP MAP program has been shown to be effective in an underserved population.[23] A common hallmark of effective implementation of these programs is a health system's ability to (1) engender widespread sustained endorsement and engagement among leaders on site at clinics and individual clinicians in adoption of standardized treatment protocols and thereby reduce therapeutic inertia[26,27]; and (2) enable frequent follow-up encounters for uncontrolled BP typically through team-based care models such as use of nonphysician health care professionals (eg medical assistants, nurses, pharmacists) to help manage hypertension.[28–31] The BP

Table 3. Difference-In-Difference Analysis Comparing the Blood Pressure Improvement Effects of the Self-Guided and Full Support BP MAP Interventions to Usual Care

BP performance metrics	Usual care clinics			Difference-in-difference between Full Support and Usual Care	*P* value*	Difference-in-difference between Self-Guided and Usual Care	*P* value†
	Baseline	At 6 months postintervention	Weighted difference				
Number of patients with hypertension	1 177 804	1 212 560	34 756	33 380		33 465	
Primary outcome							
BP control, <140/90, % of patients	61.3 (56.3 to 66.3)	60.9 (56.2 to 65.6)	−0.4 (−1.0 to 0.2)	3.2 (−0.5 to 6.9)	0.09	2.0 (−0.4 to 4.5)	0.10
Secondary outcomes							
Improvement in BP, % of patients	33.0 (30.5 to 35.5)	29.8 (27.7 to 31.8)	−3.1 (−4.1 to −2.1)‡	−0.3 (−7.2 to 6.7)	0.94	−2.2 (−5.3 to 0.8)	0.14
Confirmatory repeated BP measurement, % of visits	21.1 (10.5 to 31.7)	21.6 (10.6 to 32.5)	0.1 (−0.0 to 0.2)	19.7 (6.8 to 32.6)	0.004	11.5 (2.0 to 21.0)	0.019
Medication intensification, % of visits	10.7 (9.7 to 11.7)	10.6 (9.4 to 11.8)	−0.1 (−0.3 to 0.1)	−1.5 (−6.0 to 3.1)	0.52	−3.3 (−8.0 to 1.3)	0.16
Average systolic BP reduction after medication intensification, mm Hg	15.6 (15.1 to 16.2)	14.5 (13.9 to 15.1)	−1.1 (−1.5 to −0.8)‡	3.4 (2.0 to 4.9)	<0.001	−0.5 (−4.5 to 3.5)	0.81
Repeat visit within 4 weeks after a visit with elevated BP[4], % of visits	38.1 (35.6 to 40.5)	37.3 (34.7 to 39.8)	−0.6 (−1.0 to −0.2)‡	0.2 (−2.7 to 2.3)	0.90	−1.4 (−3.7 to 0.8)	0.21
Use of fixed dose combination medications among patients taking 2 or more classes of medications, % of patients	24.7 (21.8 to 27.6)	24.0 (21.1 to 26.9)	−0.7 (−0.8 to −0.6)‡	2.3 (−0.7 to 5.3)	0.13	0.6 (−1.1 to 2.4)	0.47
Use of a calcium channel blocker or thiazide-type diuretic among Black patients on at least 1 medication, % of patients	74.7 (72.1 to 77.3)	74.6 (71.9 to 77.3)	0.0 (−0.3 to 0.3)	−0.9 (−1.9 to 0.2)	0.10	−0.1 (−1.5 to 1.3)	0.84

Values are reported as mean (CI). BP indicates blood pressure; and MAP, Measure Accurately, Act Rapidly, and Partner With Patients.
**P* value Comparing Usual Care to Full Support intervention.
†*P* value Comparing Usual Care to Self-Guided intervention.
‡*P* value <0.05.

MAP program recommends modifications in workflows, but it does not require the restructuring clinical teams nor engagement of pharmacists or other nonphysician health care professionals in medication management for hypertension.

Our findings highlight the challenge of scaling promising quality improvement interventions across varying health care settings. The level of stakeholder activation required for clinic-level adoption of standardized evidence-based treatment protocols and structural policy and workflow needed to enact frequent follow-up encounters through team-based care may be achievable through sequential implementation at single sites and within health systems with strong central management that prioritize improvement of hypertension management.[24,26] With limited time to engage and train clinic-level stakeholders on the rationale and implementation of the program, and limited engagement of health system leadership, we found it difficult to create momentum for adoption and reinforcement of the sustained behavioral norms and workflow modifications required for transformation. Successful practice facilitation requires tailoring the components and intensity of the intervention to local contexts[32] that may vary within a multiclinic health system and across various health systems as attempted in this trial. It is likely that our intervention did not have a sufficient level of intensity (ie, engagement with local stakeholders) to produce a robust effect on BP control. *For example, we suspect there may have been low use of decision tools in both arms*. We should note, however, that even with robust stakeholder engagement, training and educational resources may not be enough to change clinician behavior toward more frequent treatment intensification. Future interventions should consider employing more hands-on strategies to automate protocolized treatment intensification and frequent follow-up, for example through routine workflows that allow nonphysician medical staff to make decisions with the use of validated electronic decision support tools for medication treatment and appointment scheduling.

Our study has limitations. The study was powered to detect a 6% difference between 2 intervention groups; the increases we measured in average clinic-level BP control could still be important (they indicate many more patients with controlled BP at each clinic), but these putative improvements were too small for us to rule out chance as an explanation with our pragmatic study design. Six of the participating clinics in this pragmatic "real-world" project underwent adoption of a new EHR system during our study period and could not implement performance reporting in their performance dashboard during part of the study period, which was a component of both versions of the intervention; a sensitivity analysis excluding these clinics yielded larger average improvements in BP control, but this post hoc analysis was not definitive. Nonrandomized group comparisons as used in our analysis are subject to residual confounding. Our robust difference-in-differences analyses minimized but could not entirely eliminate the possibility of residual confounding in comparing intervention groups to the nonrandomized Usual Care group. Despite our best efforts, we did not have enough information about Usual Care clinics to eliminate the possibility that some clinics may have had concurrent interventions or initiatives that would affect our outcomes of interest and confound our comparative analysis. However, because the Usual Care group showed no significant change in BP control or improvements in our secondary outcome measures, we are reassured that this threat to internal validity is minimal.

The study was not scoped for a robust qualitative and quantitative program evaluation. Consequently, we did not collect information on the extent of program adoption and use of the program tools and resources. Hence, we did not have adequate qualitative data to formally assess engagement with the online resources, local clinic endorsement of the goals of the study and feedback on implementation of the intervention. The "real-world" quality improvement intervention we deployed in this study was designed to be practical and scalable. We collected outcomes solely via EHR data analysis, which allowed us to evaluate the important outcomes (eg, clinic-level BP control) realistically, without extra clinic burden of collecting measurements not otherwise required for the intervention. Our process measures were known mediators of BP control[4,28,31,33,34] captured in the EHR data.

CONCLUSIONS

In summary, although some improvements in BP-related process metrics were achieved, implementation at scale of the abbreviated BP MAP program simultaneously in 24 safety net clinics across 9 health systems failed to realize a statistically significant increase in BP control compared with Usual Care, and there was no significant difference in improvements between the Full Support and Self-Guided versions of the intervention. Further research is needed to understand facilitating factors that could render the BP MAP intervention more effective, sustainable, and scalable in safety net clinics.

ARTICLE INFORMATION

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Supplemental Material

Tables S1–S6
Figures S1, S2

REFERENCES

1. Centers for Disease Control and Prevention. Underlying Cause of Death 1999–2019. http://wonder.cdc.gov/ucd-icd10.html. Accessed July 8, 2021.
2. Danaei G, Ding EL, Mozaffarian D, Taylor B, Rehm J, Murray CJL, Ezzati M. The preventable causes of death in the United States: comparative risk assessment of dietary, lifestyle, and metabolic risk factors. *PLoS Med*. 2009;6:e1000058. doi: 10.1371/journal.pmed.1000058
3. Nwankwo T, Yoon SS, Burt V, Gu Q. *Hypertension among Adults in the United States: National Health and Nutrition Examination Survey, 2011–2012*. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics; 2013;1–8.
4. Wald DS, Law M, Morris JK, Bestwick JP, Wald NJ. Combination therapy versus monotherapy in reducing blood pressure: meta-analysis on 11 000 participants from 42 trials. *Am J Med*. 2009;122:290–300. doi: 10.1016/j.amjmed.2008.09.038
5. Egan BM, Li J, Sutherland SE, Rakotz MK, Wozniak GD. Hypertension control in the United States 2009 to 2018: factors underlying falling control rates during 2015 to 2018 across age- and race-ethnicity groups. *Hypertension*. 2021;78:578–587. doi: 10.1161/HYPERTENSIONAHA.120.16418
6. Chobufo MD, Gayam V, Soluny J, Rahman EU, Enoru S, Foryoung JB, Agbor VN, Dufresne A, Nfor T. Prevalence and control rates of hypertension in the USA: 2017–2018. *Int J Cardiol Hypertens*. 2020;6:100044. doi: 10.1016/j.ijchy.2020.100044
7. Fontil V, Pletcher MJ, Khanna R, Guzman D, Victor R, Bibbins-Domingo K. Physician underutilization of effective medications for resistant hypertension at office visits in the United States: NAMCS 2006-2010. *J Gen Intern Med*. 2014;29:468–476. doi: 10.1007/s11606-013-2683-y
8. Egan BM, Sutherland SE, Rakotz M, Yang J, Hanlin RB, Davis RA, Wozniak G. Improving hypertension control in primary care with the measure accurately, act rapidly, and partner with patients protocol. *Hypertension*. 2018;72:1320–1327. doi: 10.1161/HYPERTENSIONAHA.118.11558
9. Pletcher MJ, Fontil V, Carton T, Shaw KM, Smith M, Choi S, Todd J, Chamberlain AM, O'Brien EC, Faulkner M, et al. The PCORnet blood pressure control laboratory: a platform for surveillance and efficient trials. *Circ Cardiovasc Qual Outcomes*. 2020;13:e006115. doi: 10.1161/CIRCOUTCOMES.119.006115
10. Handley MA, Lyles CR, McCulloch C, Cattamanchi A. Selecting and improving quasi-experimental designs in effectiveness and implementation research. *Annu Rev Public Health*. 2018;39:5–25. doi: 10.1146/annurev-publhealth-040617-014128
11. Itri JN, Bakow E, Probyn L, Kadom N, Duong PT, Gettle LM, Mendiratta-Lala M, Scali EP, Winokur RS, Zygmont ME, et al. The science of quality improvement. *Acad Radiol*. 2017;24:253–262. doi: 10.1016/j.acra.2016.05.010
12. Waddington H, Aloe AM, Becker BJ, Djimeu EW, Hombrados JG, Tugwell P, Wells G, Reeves B. Quasi-experimental study designs series-paper 6: risk of bias assessment. *J Clin Epidemiol*. 2017;89:43–52. doi: 10.1016/j.jclinepi.2017.02.015
13. Wing C, Simon K, Bello-Gomez RA. Designing difference in difference studies: best practices for public health policy research. *Annu Rev Public Health*. 2018;39:453–469. doi: 10.1146/annurev-publhealth-040617-013507
14. REACHnet. Research Action for Health Network. https://reachnet.org/. Accessed July 8, 2021
15. Haynes SC, Rudov L, Nauman E, Hendryx L, Angove RSM, Carton T. Engaging stakeholders to develop a patient-centered research agenda: lessons learned from the research action for health network (REACHnet). *Med Care*. 2018;56(10 Suppl 1):S27–S32. doi: 10.1097/MLR.0000000000000785
16. DeVoe JE, Gold R, Cottrell E, Bauer V, Brickman A, Puro J, Nelson C, Mayer KH, Sears A, Burdick T, et al. The ADVANCE network: accelerating data value across a national community health center network. *J Am Med Inform Assoc*. 2014;21:591–595. doi: 10.1136/amiajnl-2014-002744
17. OCHIN. A driving force for health equity. https://ochin.org/. Accessed July 8, 2021
18. DeVoe JE, Likumahuwa S, Eiff MP, Nelson CA, Carroll JE, Hill CN, Gold R, Kullberg PA. Lessons learned and challenges ahead: report from the OCHIN Safety Net West practice-based research network (PBRN). *J Am Board Fam Med*. 2012;25:560–564. doi: 10.3122/jabfm.2012.05.120141
19. Devoe JE, Sears A. The OCHIN community information network: bringing together community health centers, information technology, and data to support a patient-centered medical village. *J Am Board Fam Med*. 2013;26:271–278. doi: 10.3122/jabfm.2013.03.120234
20. Quality Payment Program. Quality ID #236 NQF #0018: controlling high blood pressure https://qpp.cms.gov/docs/QPP_quality_measure_specifications/CQM-Measures/2019_Measure_236_MIPSCQM.pdf
21. Murray M, Berwick DM. Advanced access: reducing waiting and delays in primary care. *JAMA*. 2003;289:1035–1040. doi: 10.1001/jama.289.8.1035
22. Rose KD, Ross JS, Horwitz LI. Advanced access scheduling outcomes: a systematic review. *Arch Intern Med*. 2011;171:1150–1159. doi: 10.1001/archinternmed.2011.168
23. Hanlin RB, Asif IM, Wozniak G, Sutherland SE, Shah B, Yang J, Davis RA, Bryan ST, Rakotz M, Egan BM. Measure accurately, act rapidly, and partner with patients (MAP) improves hypertension control in medically underserved patients: care coordination institute and American Medical Association hypertension control project pilot study results. *J Clin Hypertens (Greenwich)*. 2018;20:79–87. doi: 10.1111/jch.13141
24. Jaffe MG, Lee GA, Young JD, Sidney S, Go AS. Improved blood pressure control associated with a large-scale hypertension program. *JAMA*. 2013;310:699–705. doi: 10.1001/jama.2013.108769
25. Goyal A, Bornstein WA. Health system-wide quality programs to improve blood pressure control. *JAMA*. 2013;310:695–696. doi: 10.1001/jama.2013.108776
26. Fontil V, Gupta R, Moise N, Chen E, Guzman D, McCulloch CE, Bibbins-Domingo K. Adapting and evaluating a health system intervention from Kaiser Permanente to improve hypertension management and control in a large network of safety-net clinics. *Circ Cardiovasc Qual Outcomes*. 2018;11:e004386. doi: 10.1161/CIRCOUTCOMES.117.004386
27. Frieden TR, King SM, Wright JS. Protocol-based treatment of hypertension: a critical step on the pathway to progress. *JAMA*. 2014;311:21–22. doi: 10.1001/jama.2013.282615
28. Glynn LG, Murphy AW, Smith SM, Schroeder K, Fahey T. Interventions used to improve control of blood pressure in patients with hypertension. *Cochrane Database Syst Rev*. 2010;CD005182. doi: 10.1002/14651858.CD005182.pub4
29. Walsh JM, McDonald KM, Shojania KG, Sundaram V, Nayak S, Lewis R, Owens DK, Goldstein MK. Quality improvement strategies for hypertension management: a systematic review. *Med Care*. 2006;44:646–657. doi: 10.1097/01.mlr.0000220260.30768.32
30. Morgado MP, Morgado SR, Mendes LC, Pereira LJ, Castelo-Branco M. Pharmacist interventions to enhance blood pressure control and adherence to antihypertensive therapy: review and meta-analysis. *Am J Health Syst Pharm*. 2011;68:241–253. doi: 10.2146/ajhp090656
31. Fontil V, Bibbins-Domingo K, Kazi DS, Sidney S, Coxson PG, Khanna R, Victor RG, Pletcher MJ. Simulating strategies for improving control of hypertension among patients with usual source of care in the

United States: the Blood Pressure Control Model. *J Gen Intern Med*. 2015;30:1147–1155. doi: 10.1007/s11606-015-3231-8

32. Baskerville NB, Liddy C, Hogg W. Systematic review and meta-analysis of practice facilitation within primary care settings. *Ann Fam Med*. 2012;10:63–74. doi: 10.1370/afm.1312
33. Bellows BK, Ruiz-Negron N, Bibbins-Domingo K, King JB, Pletcher MJ, Moran AE, Fontil V. Clinic-based strategies to reach United States Million Hearts 2022 blood pressure control goals. *Circ Cardiovasc Qual Outcomes*. 2019;12:e005624. doi: 10.1161/CIRCOUTCOMES.118.005624
34. Xu W, Goldberg SI, Shubina M, Turchin A. Optimal systolic blood pressure target, time to intensification, and time to follow-up in treatment of hypertension: population based retrospective cohort study. *BMJ*. 2015;350:h158. doi: 10.1136/bmj.h158

Supplemental Material

Table S1. Health System-based PCORnet Datamarts Participating in BP Track, the PCORnet Blood Pressure Control Laboratory's surveillance program, that contributed to our Usual Care non-randomized control group
Pennsylvania State Medical Center
University of Chicago
Duke University
University of Kansas Medical Center
University of Pittsburgh Medical Center
Medical College Wisconsin
Marshfield Clinic
University of Florida Health
Medical University of South Carolina
Vanderbilt University
University of Nebraska
Johns Hopkins
University of Utah
Intermountain Healthcare
Indiana University
Mayo Clinic
Allina Health System
Louisiana State University

Table S2. Online digital guide resources for participating clinics

Measure Accurately	Act Rapidly	Partner With Patients
Measuring Blood Pressure A fact sheet that the most critical steps for measuring blood pressure accurately and the potential impact to measurement.	Treatment Protocols This is a fact sheet and podcast covering how your practice or health center can use an evidence-based hypertension protocol to guide treatment.	Communicating with Patients: Strategies and Skills This fact sheet and podcast promote collaborative approaches to make health care decisions with your patients, including five communication skills to help improve engagement.
Technique Quick-Check This is a check sheet that verifies that clinic staff in a practice or health center obtains blood pressure readings the right way and the same way every time.	Reducing Clinical Inertia This fact sheet and podcast cover why patients may have uncontrolled blood pressure and how to overcome these common hurdles.	Promoting Healthy Lifestyle Changes This is a fact sheet and podcast discussing the impact dietary and lifestyle changes can have on blood pressure including 5 evidence-based lifestyle changes that can significantly improve blood pressure.
Common Measurement Problems A fact sheet that displays how much a blood pressure reading can vary based on a particular patient's condition.	Treatment Algorithm Determines treatment based on blood pressure goals set according to scientific evidence, clinical judgment and patient tolerance emphasizing the importance of patient engagement.	Self-Measured Blood Pressure Monitoring at Home This is a fact sheet and podcast explaining the key steps patients must follow to effectively self-measure blood pressure, document their SMBP readings and take action to improve their blood pressure.
Measuring Blood Pressure Positioning Poster This is a poster that reminds health care teams of the proper steps to take when measuring blood pressure and provides evidence-based tips for correct positioning.	Video: BP – Acting Rapidly at Gittelman Primary Care This video highlights a medical practice that successfully implemented the M.A.P framework to improve blood pressure control among their patients.	Video: BP—Partnering with the Community at the Department of Family Medicine at MedStar Health This video highlights a medical practice that successfully implemented the M.A.P. framework to improve blood pressure control among their patients**.**
Video: BP – Measuring accurately at Erie Family Health Center This video highlights a medical practice that successfully implemented the M.A.P framework to improve blood pressure control among their patients.		Use strategies in your health care setting that can help promote medication adherence This is a fact sheet with best practices for providing patient education and drug prescription (e.g. daily dosing, single-pill combinations, 90-day dispensing) geared toward promoting medication adherence.
Measuring BP Accurately This is a fact sheet and podcast that cover the importance of accurate blood pressure measurement as well as evidence-based steps for a practice to achieve accurate measures.		

Table S3. Downloadable online digital guide resources for patient education on self-management

About High Blood Pressure	Treatment Of High Blood Pressure	Monitoring High Blood Pressure
Overview This overview reviews the basics of high blood pressure, including key stats and information about risk factors and medication.	Steps to Improve Blood Pressure This patient resource identifies five lifestyle modifications that can be made to improve blood pressure.	Monitoring Cholesterol, Blood Pressure and Weight Your patients need to understand that high cholesterol, high blood pressure, and/or being overweight or obese puts them at increased risk for heart disease or stroke. This handout encourages patients to work with you to determine their risk and how to manage it.
Reaching Your Ideal Blood Pressure This flyer teaches patients how to check their blood pressure in three simple steps. It then offers tips for reaching their blood pressure goals.	Sodium (salt) and Your Blood Pressure This handout discusses how the body uses sodium and why too much salt can be problematic. It also offers tips on foods to avoid and how to cook with less salt.	How to Measure Blood Pressure at Home This handout explains the importance of self-measuring blood pressure, choosing a blood pressure monitoring device, and measuring blood pressure accurately at home
Blood Pressure Causes (slide show) Patients are offered a unique and interactive look at the anatomy of the heart.	Blood Pressure Medication This patient resource discusses the different medicines prescribed to help lower blood pressure, as well as possible side effects	Positioning for At-Home Blood Pressure Measurement This handout provides your patients with specific, step-by-step techniques to use to effectively take their own blood pressure.
Seven Steps to Calculate and Improve My “Heart Health Score” Patients are offered a unique and interactive look at the anatomy of the heart.	Managing Medication This handout addresses questions about taking blood pressure medication. It also includes a chart to help track medication use.	At-Home Blood Pressure Measurement Log This form available for patients to record their morning and evening blood pressure readings
Medical Complications Related to High Blood Pressure This infographic describes some of the consequences of high blood pressure.	Questions to Ask Your Doctor Patients often have questions but aren’t sure how to ask them. This handout offers examples of common questions specific to understanding blood pressure and the management of it.	
High Blood Pressure and Stroke This handout explains the risks associated with high blood pressure, especially stroke	Sodium (salt) Myths Patients have many misconceptions about salt. This poster dispels 7 common myths about salt.	
	High Blood Pressure and Heart Disease (slide show) This interactive way for your patients to learn more about how high blood pressure affects their arteries and heart.	

Table S4. Blood Pressure Control Metrics developed by the PCORnet Blood Pressure Control Laboratory and used as outcomes in the study[1]

#	Metric	Description
1	Blood Pressure Control (<140/<90 mm Hg), % of patients	This overall measure of BP control implements NQF 0018,[2] which defines BP Control as the percent of eligible hypertensive patients for whom the BP measurements at their most recent ambulatory care visit were at goal, defined as systolic BP (SBP) < 140 mm Hg and diastolic BP (DBP) < 90 mm Hg.
2	Improvement in Blood Pressure, % of patients	This overall measure of BP improvement implements CMS065v7,[3] which defines BP improvement as either a reduction of 10 mmHg in SBP or achievement of SBP that is "adequately controlled" (SBP < 140 mmHg) in months 10-12 of the measurement period, among hypertensive patients with an SBP not previously controlled.
3	Confirmatory Repeated Blood Pressure Measurement, % of visits	This process measure is designed to capture the practice of repeating a BP measurement in the same visit when the first measurement done in clinic is high (SBP≥140 mm Hg or DBP≥90 mm Hg).
4	Medication Intensification, % of visits	This process measure captures the proportion of visits where BP is uncontrolled where a BP medication is prescribed that is of a different class of medication than had previously been used. Note that this explicitly does not give credit for ordering a simple refill or medication dose increase, or use of a different medication in the same class.
5	Average SBP Change After Medication Intensification, mm Hg	This continuous metric describes the average change in SBP ± standard deviation observed between a visit with a medication intensification to the subsequent visit occurring at least 10 days later.
6	Repeat Visit in 4 Weeks After Uncontrolled HTN, % of visits	This process measure captures the proportion of visits by persons with uncontrolled HTN that were followed by a subsequent visit within 4 weeks.
7	Prescription of Fixed Dose Combination Product Among Patients Prescribed At Least 2 Classes of Medications, % of patients	Use of fixed dose combination medications helps with adherence, promotes rational combinations of medications, increases likelihood of achieving BP control and is recommended[4]. This metric, which is limited to patients taking at least two BP medication classes, describes the prevalence of fixed dose combination medication use.
8	Prescription of a CCB or Thiazide or Thiazide-Like Diuretic among Black Patients Prescribed At Least One Medication, % of patients	Use of a calcium channel blocker (CCB) OR a thiazide or thiazide-like diuretic medication is recommended to treat Black or African American patients as first line monotherapy due to increased efficacy.[4] This metric, which is limited to Black patients with a diagnosis of hypertension prescribed at least one medication class, describes the prevalence of those prescribed a CCB or a thiazide or thiazide-like diuretic.

Table S5. Difference-in-differences analysis, with and without adjustment, comparing outcomes in the 3 arms of the study.						
	Self-Guided vs Usual care		Full Support vs Usual care		Full Support vs Self-Guided	
	Unadjusted	Adjusted[1]	Unadjusted	Adjusted*	Unadjusted	Adjusted[1]
Primary outcome						
BP control, %	2.0 (-0.4, 4.5)	2.1 (0.8, 3.3)†	3.2 (-0.5, 6.9)	3.1 (1.3, 4.9)†	1.2 (-3.2, 5.6)	1.1 (-1.1, 3.2)
Secondary outcomes						
Improvement in BP, %	-2.2 (-5.3, 0.8)	-2.5 (-5.1, 0.1)	-0.3 (-7.2, 6.7)	-2.5 (-5.1, 0.1)	2.0 (-5.5, 9.4))	0.3 (-3.9, 4.5)
Confirmatory Repeated Blood Pressure Measurement, % of visits	11.5 (2.0, 21.0)	9.5 (5.8, 13.1)	19.7 (6.8, 32.6)†	13.0 (6.7, 19.4))†	8.2 (-7.9, 24.2	3.6 (-3.8, 10.9)
Medication intensification, %	-3.3 (-8.0, 1.3)	-5.1 (-8.3, -1.8	-1.5 (-6.0, 3.1)	-2.1 (-5.9, 1.7)	1.9 (-4.7, 8.5)	3.0 (-2.0, 7.9)
Average SBP Reduction After Medication Intensification, mmHg	-0.5 (-4.5, 3.5)	-3.1 (-7.2, 0.9)	3.4 (2.0, 4.9)†	2.3 (-3.0, 7.6)	3.7 (-0.6, 7.9)	5.5 (-1.1, 12.1)
Repeat visit within 4 weeks after a visit with elevated BP[2]	-1.4 (-3.7, 0.8)	-0.9 (-3.2, 1.4)	0.2 (-2.7, 2.3)	-0.5 (-3.3, 2.3)	1.3 (-2.0, 4.6)	0.4 (-3.2, 4.0)
Use of fixed dose combination, % medications among patients taking 2 or more classes of medications, %	0.6 (-1.1, 2.4)	1.0 (-0.1, 2.2)	2.3 (-0.7, 5.3)	1.9 (0.4, 3.5)	1.7 (-1.8, 5.2)	0.9 (-1.0, 2.8)
Use of a CCB or thiazide-type diuretic among African-American patients on one medication %	-0.1 (-1.5, 1.3)	0.0 (-1.5, 1.5)	-0.9 (-1.9, 0.2)	-0.6 (-1.8, 0.5)	-0.7 (-2.4, 0.9)	-0.6 (-2.5, 1.3)

*Adjusted for age, sex and race
†P-value <0.005

Table S6. Unadjusted difference-in-difference analysis comparing results in the 3 arms of the study: A post-hoc sensitivity analysis excluding six clinics that changed their EHR vendor during the study period

BP performance metrics	Difference-in-difference between Full Support and Self-Guided	P-value[1]	Difference-in-difference between Full Support and Usual Care	P-value[2]	Difference-in-difference between Self-Guided and Usual Care	P-value[3]
Primary outcome						
BP control (<140/90), % of patients	2.0 (-3.1, 7.1)	0.43	5.1 (0.7, 9.5)	0.02	3.2 (0.4, 5.9)	0.03
Secondary outcomes						
Improvement in BP, % of patients	4.6 (-2.9, 12.2)	0.22	4.1 (-2.9, 11.2)	0.24	-0.6 (-3.5, 2.4)	0.70
Confirmatory Repeated Blood Pressure Measurement, % of visits	11.8 (-5.9, 29.6)	0.18	30.6 (20.0, 41.2)	<0.011	18.8 (4.6, 33.0)	0.01
Medication intensification, % of visits	1.0 (-3.2, 5.3)	0.62	1.2 (-2.2, 4.5)	0.48	0.1 (-2.5, 2.8)	0.91
Average SBP Reduction After Medication Intensification, mmHg	1.4 (-1.8, 4.6)	0.37	3.3 (1.8, 4.8)	<0.001	1.9 (-1.0, 4.7)	0.20
Repeat visit within 4 weeks after a visit with elevated BP[4], % of visits	3.7 (0.2, 7.3)	0.04	0.3 (-3.0, 3.7)	0.84	-3.4 (-4.7, -2.1)	<0.001
Use of fixed dose combination medications among patients taking 2 or more classes of medications, % of patients	3.1 (-1.3, 7.4)	0.16	3.7 (0.1, 7.4)	0.05	0.7 (-1.7, 3.0)	0.56
Use of a CCB or thiazide-type diuretic among African-American patients on at least one medication, % of patients	1.3 (-1.3, 3.9)	0.31	0.3 (-1.9, 2.5)	0.79	-1.0 (-2.4, 0.3)	0.14

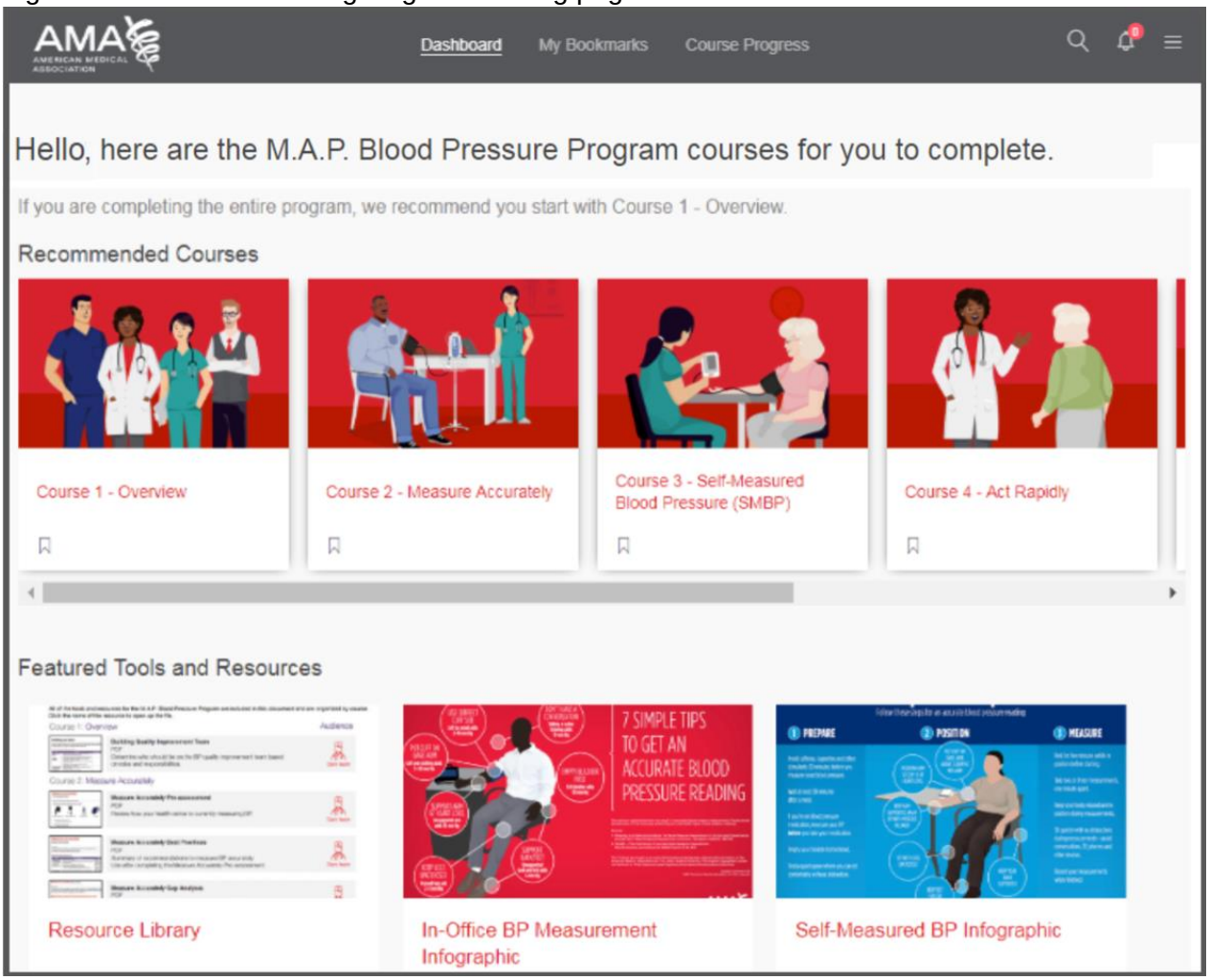
BP=blood pressure, CCB=calcium channel blocker

P-value[1] Comparing Full Support intervention to Self-Guided intervention

P-value[2] Comparing Usual Care to Full Support intervention

P-value[3] Comparing Usual Care to Self-Guided intervention

Figure S1. Screenshot of digital guide landing page



To help clinics implement M.A.P. BP in this study, the AMA developed an extensive set of materials that are available online as a “digital guide” organized according *to the M.A.P. framework.* Stakeholders from each clinic participating in the trial were required to attend a webinar explaining the registration process and use of the digital guide, after which all participants were instructed to register for their own unique account to access the program content on the Digital Guide website. User registration required the participant’s name, email, health center ID, job role, and role in the MAP BP program implementation and two-factor authentication.

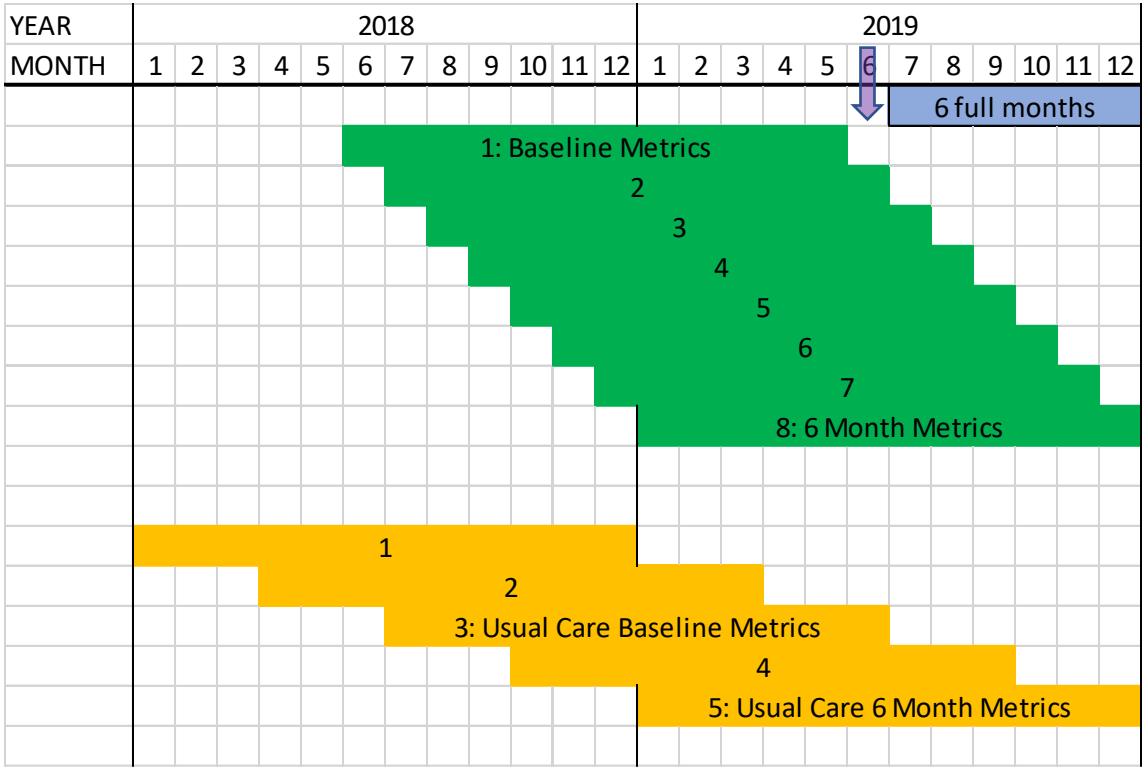


Figure S2. Measurement periods used for baseline and 6 month time points for Full Support and Self-Guided intervention clinics, and for Usual Care health systems. We defined BP Control Metrics for a series of 1-year measurement periods using identical methods for each measurement period (green and orange bars).

For intervention clinics (Full Support and Self-Guided interventions), metrics were calculated on a monthly basis (green bars). Baseline metrics were calculated using the 1-year measurement period ending the month prior to the Kickoff (illustrated above with a purple arrow), and at the 6-month time point using the 1-year measurement period ending at least 6 months after initiation of the intervention. Because initiation of the intervention occurred during the middle of a calendar month, the two queries were 7 months apart. Dates shown above are for REACHnet intervention clinics (with Kickoffs all occurring in June 2019); OCHIN intervention clinic Kickoffs (and corresponding intervention measurement periods) occurred 1 month later (in July 2019).

For the Usual Care health systems, we used measurements from BP Track, an ongoing surveillance project supported by the Blood Pressure Control Laboratory, which calculates BP Control Metrics on a quarterly basis (orange bars). We used two quarterly measurement periods 6 months apart, essentially concordant in time, for the baseline and 6-month time points.