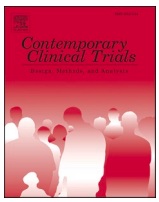
Contemporary Clinical Trials 138 (2024) 107466

Contents lists available at ScienceDirect

Contemporary Clinical Trials

journal homepage: www.elsevier.com/locate/conclintrial



Design of a pragmatic randomized implementation effectiveness trial testing a health system wide hypertension program for older adults

Aditi Gupta [a,b,*], Hira Chouhdry [a], Shellie D. Ellis [c], Kate Young [d], Jonathan Mahnken [d], Branden Comfort [e], Denton Shanks [f], Sheila McGreevy [e], Courtney Rudy [e], Tahira Zufer [f], Sharissa Mabry [f], Jennifer Woodward [f], Amber Wilson [b], Heidi Anderson [b], Jennifer Loucks [g], Sravani Chandaka [h], Noor Abu-el-rub [h], Diego R. Mazzotti [h,i], Xing Song [j], Nolan Schmitz [g], Molly Conroy [k], Mark A. Supiano [l], Lemuel R. Waitman [j], Jeffrey M. Burns [b]

[a] Division of Nephrology and Hypertension, Department of Internal Medicine, University of Kansas Medical Center, Kansas City, KS, United States
[b] Department of Neurology, University of Kansas Medical Center, Kansas City, KS, United States
[c] Department of Population Health, University of Kansas Medical Center, Kansas City, KS, United States
[d] Department of Biostatistics and Data Science, University of Kansas Medical Center, Kansas City, KS, United States
[e] Division of General Internal Medicine, Department of Internal Medicine, University of Kansas Medical Center, Kansas City, KS, United States
[f] Department of Family Medicine, University of Kansas Medical Center, Kansas City, KS, United States
[g] Department of Pharmacy, University of Kansas Health System, Kansas City, KS, United States
[h] Division of Medical Informatics, Department of Internal Medicine, University of Kansas Medical Center, Kansas City, KS, United States
[i] Division of Pulmonary, Critical Care and Sleep Medicine, Department of Internal Medicine, University of Kansas Medical Center, Kansas City, KS, United States
[j] Department of Biomedical Informatics, Biostatistics, and Medical Epidemiology, University of Missouri, Columbia, MO, United States
[k] Division of General Internal Medicine, Department of Internal Medicine, University of Utah Spencer Fox Eccles School of Medicine, University of Utah, Salt Lake City, UT, United States
[l] Geriatrics Division, Department of Internal Medicine, University of Utah Spencer Fox Eccles School of Medicine and Center on Aging, University of Utah, Salt Lake City, UT, United States

ARTICLE INFO

Keywords:
Hypertension
Implementation
Remote patient monitoring
SMBP
Alzheimer's disease

ABSTRACT

Hypertension control remains poor. Multiple barriers at the level of patients, providers, and health systems interfere with implementation of hypertension guidelines and effective lowering of BP. Some strategies such as self-measured blood pressure (SMBP) and remote management by pharmacists are safe and effectively lower BP but have not been effectively implemented. In this study, we combine such evidence-based strategies to build a remote hypertension program and test its effectiveness and implementation in large health systems. This randomized, controlled, pragmatic type I hybrid implementation effectiveness trial will examine the virtual collaborative care clinic (vCCC), a hypertension program that integrates automated patient identification, SMBP, remote BP monitoring by trained health system pharmacists, and frequent patient-provider communication. We will randomize 1000 patients with uncontrolled hypertension from two large health systems in a 1:1 ratio to either vCCC or control (usual care with education) groups for a 2-year intervention. Outcome measures including BP measurements, cognitive function, and a symptom checklist will be completed during study visits. Other outcome measures of cardiovascular events, mortality, and health care utilization will be assessed using Medicare data. For the primary outcome of proportion achieving BP control (defined as systolic BP < 130 mmHg) in the two groups, we will use a generalized linear mixed model analysis. Implementation outcomes include acceptability and feasibility of the program. This study will guide implementation of a hypertension program within large health systems to effectively lower BP.

* Corresponding author at: Internal Medicine and Neurology, Clinical Trials, Hoglund Biomedical Imaging Center, Internal Medicine Residency Research, Division of Nephrology and Hypertension, Department of Internal Medicine and Department of Neurology, University of Kansas Medical Center, 3901 Rainbow Blvd, Kansas City, KS 66160, United States.
E-mail address: agupta@kumc.edu (A. Gupta).

https://doi.org/10.1016/j.cct.2024.107466
Received 30 October 2023; Received in revised form 22 January 2024; Accepted 5 February 2024
Available online 7 February 2024

1. Background

The benefits of lowering blood pressure (BP) are well established [1,2]. Even modest reductions in BP can significantly reduce cognitive impairment, cardiovascular events, and mortality [3]. Inability to control BP is a missed opportunity to prevent morbidity and mortality.

Current practices for managing hypertension are imperfect. Patients usually see their primary care provider (PCP) ~1.5 times a year [4] and most PCPs are allocated ~15 min for a follow up visit. The PCP-patient contact may thus be insufficient to promote an effective dialogue for shared decision making on BP control. In addition, clinic-based BP are often inaccurate [5,6]. Home based BP measurements or self-measured blood pressures (SMBP) have benefits over clinic-based BP measurements. SMBP allows more frequent BP readings and more accurate estimates of BP and its diurnal variations [7]. In addition, SMBP can be effectively monitored by PCP team members such as pharmacists. When combined with remote monitoring and management, SMBP, if properly implemented, can provide more frequent follow-up, quicker adjustments in medications, improved patient knowledge, and empowerment [7–9]. SMBP is also preferred by patients over in-clinic assessments and remote monitoring with SMBP is safe and effective [7]. Despite these data, SMBP and remote management of hypertension are not widely implemented.

The American College of Cardiology and American Heart Association guidelines (ACC/AHA) recommend lowering systolic BP (SBP) to <130 mmHg [1]. Most patients with hypertension do not achieve this goal. Many barriers at the patient, provider, and organizational level interfere with implementation of these guidelines and effective lowering of BP (Table 1) [10–24]. These barriers are largely surmountable by reorganization of the current model of hypertension management and leveraging new technology, implementation science, and team-based system-wide processes.

After interviewing several physicians about the barriers to BP lowering [25] and reviewing published data, we developed a hypertension program that is practical and is likely to be welcomed by stakeholders (Table 1). PCPs recognize the need for help with the extra work associated with SMBP. Our virtual collaborative care clinic (vCCC) offers solutions to current barriers as indicated in Table 1 and uses a combination of evidence-based strategies integrated into the clinic workflow. This program is designed with stakeholder input and incorporates technology to lower patient and PCP burden. The unique combination of design elements that increase the efficiency in managing hypertension (e.g., automated identification of patients, BP dashboard, remote monitoring) make it highly acceptable among patients, PCPs, and health systems.

In this study, we will test the effectiveness and implementation of the vCCC. The primary objective is to determine the effectiveness of the vCCC in lowering SBP in patients with uncontrolled hypertension compared to usual care. Secondary objectives are to assess implementation of the hypertension program and the benefits of BP lowering. Secondary outcomes include change in cognitive function, atherosclerotic cardiovascular disease risk (ASCVD), major adverse cardiovascular events (MACE), health care resource utilization, and mortality. Implementation outcomes relevant to system wide adoption and replicability in other health systems, include feasibility, acceptability, appropriateness, and intention to adopt the vCCC among PCPs, front-line administrators, and health system leaders.

We hypothesize that health-system wide adoption of vCCC will improve BP control in patients with previously uncontrolled hypertension, slow cognitive decline, and reduce cardiovascular events, mortality, and health care utilization.

Table 1
Multilevel barriers to BP control and solutions to these barriers with the vCCC [25].

	Current barriers to hypertension management	Solutions to these barriers with our program
Patient level	Poor access to high quality care, lack of knowledge [15,16]	Improved access to care and education on hypertension
	Inaccurately measured BP, use of non-validated cuffs	Education on correct method for measuring BP, use of a validated FDA approved BP cuff
	Adherence to treatment [17–19]	vCCC follow-up to address medication tolerance and adherence to treatment. Consideration of dosing frequency and cost while prescribing [26]
	Logistical issues: access to care, distance from clinic, lack of time for clinic visits, transportation	Improved access with phone visits, e-scripts, and mail orders
Provider level	Lack of clinical decision support or treatment algorithms, clinical inertia, lack of provider time, lack of physician incentives [10–14]	Evidence-guided algorithms, BP dashboard with individualized BP goals. Regular feedback to providers on patient outcomes [27–29].
	Inability to set accurate BP goals due to inaccurate in-clinic BP, masked hypertension, or white coat hypertension	Use of SMBP to avoid over-correction of white coat hypertension [30] and under-correction of masked hypertension [31]
	Limited time and resources for patient counseling in an already busy clinic	Additional opportunities for patient counseling during vCCC visits
System level	Lack of providers, clinic space, and resources for timely follow up [10–14,20]	Phone visits, without the need for additional clinic space. vCCC pharmacists can work remotely.
	Poor patient-physician communication [18], long periods of time in-between clinic visits	Increased frequency of follow-up and communication in between regular clinic visits
	Lack of decision support tools or their implementation, and lack of feedback [21–24]	Decision support tools and periodic feedback [27,28]
	Improper and inconsistent BP measuring techniques [32]	Use of SMBP after education on the correct method

vCCC; virtual collaborative care clinic, BP; blood pressure, SMBP; self-measured blood pressure monitoring, PCP; primary care provider.

2. Methods

2.1. Study organization and design

This is a randomized, controlled, pragmatic, type I hybrid effectiveness-implementation trial that will examine the effect of vCCC, a remote hypertension program integrating automated patient identification and referral, SMBP, remote BP monitoring by trained clinical pharmacists, and frequent phone communications between the pharmacist and the patients, without additional workload for the PCP. The study will be conducted in two large health systems, the University of Kansas Health System, and the University of Utah. The trial is funded by the NIH (R33AG068483) and is registered in clinicaltrials.gov (NCT5138601). An NIH appointed data and safety monitoring board (DSMB) will monitor progress and safety of the study and make the decisions about continuation of the study. Possible reasons for discontinuation of the study include safety concerns, low retention, and lack of support from the health system.

We will randomize 1000 patients with uncontrolled hypertension (as defined in the inclusion criteria in Table 2) in a 1:1 ratio to either vCCC or control group (usual care with education). Patients will be enrolled for a 2-year period. The Central Coordinating Team will be based at University of Kansas Medical Center. Each site will have a study team and a clinical team. The study team will consist of study investigators, regulatory personnel, project manager, study coordinators, statisticians,

Table 2
Inclusion and exclusion criteria.

Inclusion criteria	• Age 65 years and older • Active patient in participating primary care clinics. • Meeting one of the BP criteria 1) Elevated BP as defined: SBP >140 mmHg at current visit AND documented history of hypertension OR SBP > 140 mmHg at current visit and at another visit in last 18 months OR SBP >160 mmHg at current visit 2) Referred to the study by their PCP for uncontrolled BP (SBP reading >140 mmHg in the last 3 months)
Exclusion criteria	• Sufficiently fluent in English and adequate hearing to complete study procedures. • Able to give their own signed consent. • Covered by Medicare. • Participants who require the alternate device (those requiring an extra-large cuff or have an electrical device such as a cardiac pacemaker or defibrillator) will be required to have access to a compatible "smartphone" or device (i.e., Android, Kindle, or Apple with internet connectivity or mobile network) • Clinically significant illness that may affect safety or completion per their treating PCP or study physician. • Currently in hospice care • Currently receiving chemotherapy • Unable to take accurate BP measurement, e.g., lymphedema or dialysis access on both arms. • Currently participating in another intervention trial • On dialysis • Diagnosis of dementia • Chronic active disease with expected life expectancy <2 years as determined by the study team.

BP; blood pressure, SBP; systolic blood pressure, CKD; chronic kidney disease, eGFR; estimated glomerular filtration rate, CVD; cardiovascular disease, ACS; acute coronary syndrome, MI; myocardial infarction, PCI; percutaneous coronary intervention, CABG, coronary artery bypass grafting.

psychometrists, and medical informatics personnel and will be involved in screening, recruitment and consenting, randomization, referral to the vCCC, outcome assessments, collection and monitoring of adverse events and study outcomes, data management, and study closure. The clinical team will consist of PCPs, and clinical pharmacists and technicians working with the PCPs. With the pragmatic design, the study intervention and hypertension management will be carried out by the health systems' pharmacists working closely with the PCPs, and not the study team.

2.2. Patient eligibility

The inclusion and exclusion criteria are described in Table 2. Patients aged 65 years or more with uncontrolled BP during their clinic visits will be enrolled. With the pragmatic nature of the study, the exclusion criteria are limited. Lack of adherence to medical treatment does not exclude participation. The study aims to educate patients and help with adherence. Patient selection is automated. However, interested patients can approach their PCP and be referred to the study (Table 2).

2.3. Enrollment

This is a health system study where patients with uncontrolled hypertension are automatically identified and screened through the electronic health record (EHR). The EHR based screening algorithm will identify patients who have SBP > 140 mmHg, are 65 years or older, speak English, and have Medicare insurance (some outcomes are assessed through Medicare Claims Data) and exclude those with dementia, kidney failure, or needing an interpreter. Patients meeting initial eligibility criteria will automatically be 'referred' to the study team for further screening by study coordinators.

After chart review and pre-screening, eligible patients will be contacted within 2 weeks of their last clinic visit. Interested patients will be sent a consent form, either electronically via email or a hard copy through regular mail and scheduled for an informed consent visit (Visit 0, ~30 min) (Table 3). Following informed consent, a baseline visit will be scheduled. Participants will be mailed education materials with information on the importance of BP control, SMBP, correct method of measuring BP at home, and details about the study. An electronic home BP monitoring device will be mailed to the participant to prepare them for the baseline visit. All study visits will be done remotely via phone.

2.4. Baseline visit

During the baseline visit (~90 min), the study coordinator will discuss the correct method for SMBP and collect BP measurements using study BP monitors. Participants will also complete a baseline symptom checklist. After BP assessment, a 1-h Telephone Cognitive Assessment (T-Cog) will be conducted. The T-cog is used by the National Alzheimer's Coordinating Centers and includes the Rey Auditory Verbal Learning Test, Number Span Test (forward and backward), Category Fluency (animals, vegetables), Verbal Fluency (F and L words), Montreal Cognitive Assessment (MoCA-Blind), Oral Trail Making Test A & B, and Verbal naming Test [33].

2.5. Randomization

Randomization will be completed following the baseline visit. Participants will be assigned to either the control (usual care with education) or the active intervention (vCCC) group in a 1:1 ratio stratified by the PCP, so that there is equal probability of assignment of patients under one PCP into both groups. Study coordinators administering outcome measures will be blinded to the participant's randomization to the intervention arm. An unblinded coordinator will complete the randomization process within the Research Electronic Data Capture (REDCap) [34,35] system and notify the participant of their assignment at the end of the baseline visit.

2.6. Study intervention

Patients randomized to the vCCC group will be enrolled into the vCCC by the unblinded study team member. These patients will work with the vCCC pharmacists, in addition to their usual primary care visits. The pharmacists will have access to the Qardio BP dashboard (Qardio Inc.) that displays SMBP readings and follows a traffic light system to alert the pharmacists of BPs that are out of desired range for that patient. The vCCC pharmacists will monitor SMBPs and BP alerts and discuss medication options, medication tolerance and adherence, and affordability, and help patients achieve goal SBP. The vCCC pharmacists will use MyChart, EHR, or phone to communicate with the patients. The pharmacists will also review the appropriate technique for BP measurements and determine the frequency of SMBP needed. They will prescribe and adjust medications (with authorization and co-signature from PCPs) and monitor for side effects of medications in communication with the patient's PCP. The pharmacists will maintain a regular follow up with patients through phone calls, at least monthly or as often as needed, to encourage behavioral interventions and address barriers to adherence to medications or SMBP. This task will be shared by the clinical pharmacists according to the clinics assigned to them. The number of patients assigned to a pharmacist will be decided in consultation with their supervisors. Approximate time allocations were based on the experiences from the pilot study [36]. On an average, a pharmacist is will have ~50 study patients under their care at one point in time and 30–60 min of dedicated administrative time daily to review vCCC patients in the Qardio dashboard. Pharmacists will also have scheduled visits (~30 min) with patients at clinically appropriate intervals. However, as the study progresses and BP control improves, the time needed will decrease. The clinical pharmacists will aim for a goal

Table 3
Schedule of study visits.

Procedure	Recruitment	Baseline	4-Month Phone Call	8-Month Phone Call	12-Month Visit	16-Month Phone Call	20-Month Phone Call	24-Month Visit
Visit Number	Visit 0	Visit 1	Visit 2	Visit 3	Visit 4	Visit 5	Visit 6	Visit 7
Informed Consent	X							
Symptom Checklist		X	X	X	X	X	X	X
BP Measure		X			X			X
T-cog		X			X			X
Acceptability and Satisfaction Survey					X			X
Randomization*		X						

BP; blood pressure, T-cog; telephone cognitive assessment.
* Randomization occurs at the end of the baseline visit (after outcome assessments are completed).

SBP of <130 mmHg, as recommended by the current ACC/AHA guidelines [1], but can change the goal BP as appropriate, e.g., in symptomatic orthostatic hypotension.

Patients in the control arm will continue to follow with their PCP without support or intervention from the vCCC. They will receive educational materials and BP monitoring device prior to the baseline visit. They will check their BP per their discretion or as advised by their PCP. Their BP will not be monitored via a BP dashboard.

2.7. Follow-up study visits

Outcome assessment phone visits will occur at Month 12 and Month 24 (end of study). These visits consist of BP measurement, T-cog, and the symptom checklist. In addition, a study team member will perform brief phone calls with all patients at months 4, 8, 16, and 20 to encourage retention and administer the symptom checklist.

Although the number of visits is high (seven visits in two years), less frequent visits can affect participant engagement. All visits are phone calls making it easier for the participants. Moreover, participants were very accepting of the visit duration in the pilot study [36].

2.8. Safety monitoring

We considered the pragmatic nature of the trial using FDA-approved medications with known safety profile and the importance of mitigating the study team's potential interference with care to preserve the integrity of the study. The European Clinical Trial Regulations have suggested simplifying reporting adverse events for pragmatic-based trials [37]. To best balance safety with the pragmatic goals of the study, we will collect patient-reported symptoms that may be associated with hypertension or hypertension-medication management using a symptom checklist. The pragmatic nature of this trial dictates that serious adverse events will be managed by the patient's clinical care team per standard practice. To further ensure the safety of the study, unblinded statisticians will submit closed reports including the symptom checklist to the DSMB.

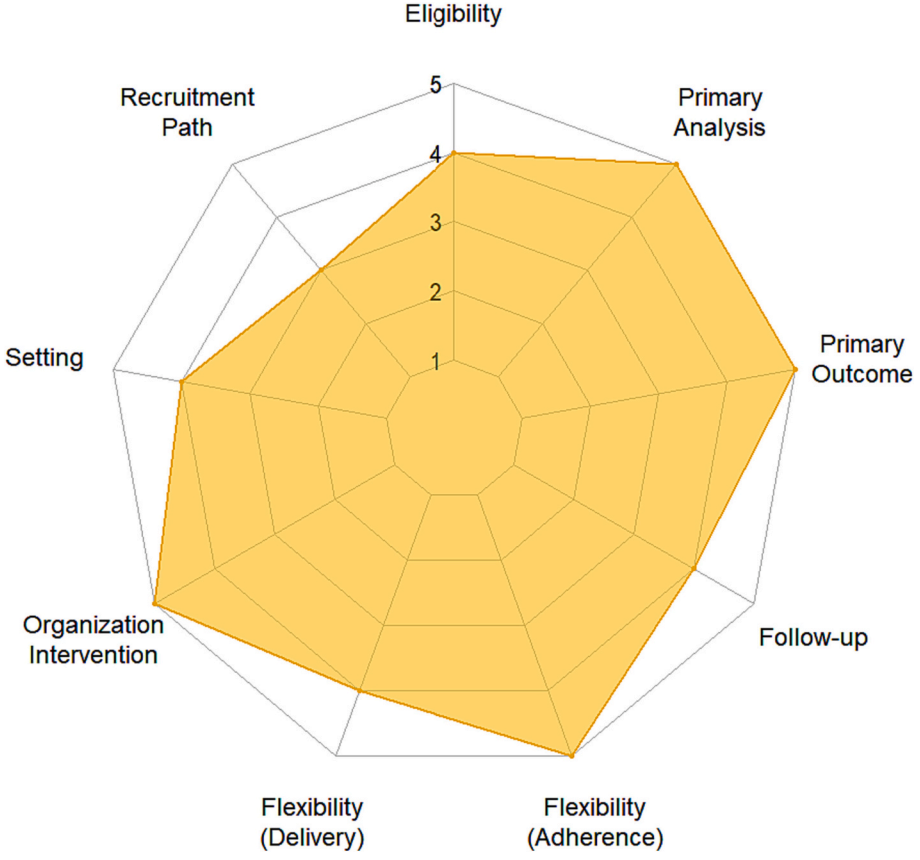


Fig. 1. Pragmatic Explanatory Continuum Indicator Summary (PRECIS-2) wheel for the study.

3. Implementation outcomes

All PCPs and front-line nursing staff from participating clinics and relevant health system administrators will be surveyed at baseline, 12 months, and at the end of the study. Additionally, a semi-structured interview guide based on Tailored Implementation for Chronic Disease [38] will be used to interview selected PCPs, administrators, and health system leaders after 18 months of intervention within each health system to assess barriers and facilitators of successful implementation of the vCCC. The vCCC pharmacists will also be interviewed to assess implementation factors including the auto-referral process, BP dashboard, issues with SMBP, BP management, and patient and interprofessional barriers and facilitators to implementation. The study is highly pragmatic as indicated in the Pragmatic Explanatory Continuum Indicator Summary (PRECIS-2) wheel [39] (Fig. 1) for the study. The broad eligibility criteria, automated referral for the study, intervention delivery by health system pharmacists (and not the study team), majority of outcome assessments via medical records, and remote study visits make the study more pragmatic than explanatory.

4. Data management

The overall data architecture for the study is shown in Fig. 2. Study data from both sites will be collected and managed in REDCap [34,35], a secure Web based data capture system hosted on a HIPAA compliant server and using the PCORnet common data model (CDM) derived from routinely collected EHR data [40,41]. We will use REDCap for randomization, study specific data collection, integrating SMBP, and data quality and monitoring of accrual and adverse events. In addition to aggregating EHR data such as BP, comorbidities, and medication exposure, the PCORnet CDM will also record study enrollment in the PCORnet_TRIAL table [42]. Finally, the two CDMs will be integrated and linked to Center of Medicare and Medicaid (CMS) administrative claims [43] to conduct the final secondary analyses and understand health care resource utilization both inside as well as services received outside the two health systems.

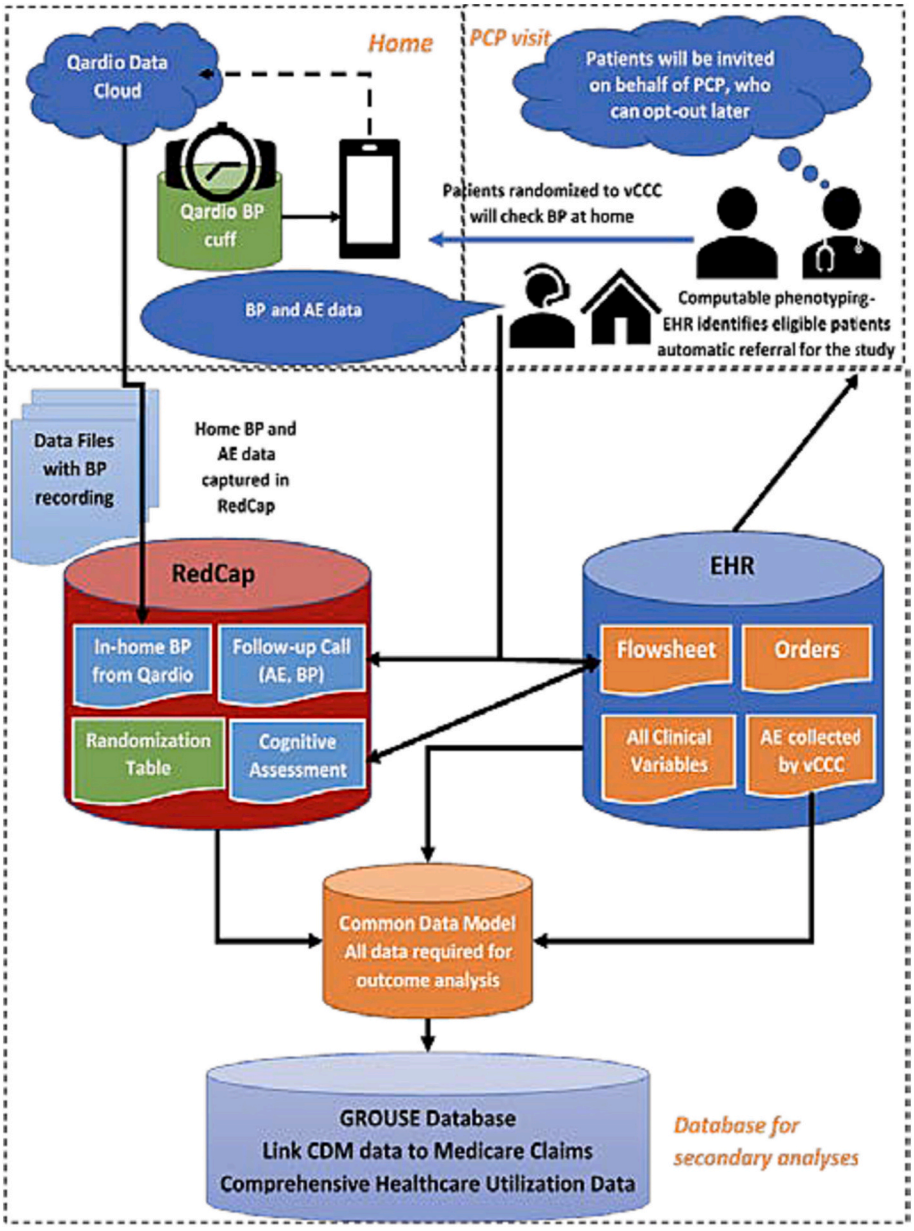


Fig. 2. Data architecture for the study showing integrating points between the Electronic Health Record (EHR), REDCap, Qardio, PCORnet Common Data Model (CDM) and Medicare Claims data.

Outcomes such as MACE, ASCVD risk scores, health utilization and all-cause mortality (Table 4) will be ascertained by combining patient generated and reported outcomes with PCORnet CDM and CMS data for complete capture. MACE is a composite endpoint combining hospitalization for myocardial infarction (MI), nonfatal stroke, coronary revascularization, and heart failure identified by pre-defined ICD and CPT codes [44,45]. The 10-year ASCVD risk score will be derived at baseline and 24 months to allow estimation of the change in risk of cardiovascular disease with the intervention [46]. Data to calculate the ASCVD scores are available in the EHR. The health utilization outcome measurements will include healthcare-facility-metrics, such as carrier (physician Part B) claims and charges per patient, outpatient, inpatient, skilled nursing facility claims and charges per patient; component-of-care metrics, such as coronary care claims and expenditures per patient, coronary care unit days and intensive care unit days per patient, general drugs and/or intravenous therapy claims per patient, durable medical equipment Medicare payments per patient, imaging and laboratory events and expenditures per patient [47]. All-cause mortality is a composite endpoint defined as death from any cause, which will be ascertained by Social Security Death Master File [48], Hospital death records, CMS death data [49], and obituary data.

4.1. Data analysis

A generalized linear mixed model (GLMM) will be used to examine differences in proportions achieving BP control (defined as SBP <130 mmHg, averaged between three BP readings at the outcome assessment visits) between vCCC and control arms at 12 and 24 months. The GLMM framework includes the ability to model dichotomous data (i.e., BP controlled vs. not controlled) with treatment group, time, and their interaction as explanatory variables. Additionally, a fixed effect for site will be included in the GLMM. We will include a random intercept term for each subject to account for correlation induced between measures within-subject over time. The Benjamini-Hochberg approach will be used to control for multiple testing of treatment effects at 12 and 24 months. Secondary analysis will also be performed with BPs recorded a) in the EHR and b) with SMBP. We will calculate the correlation between clinic BP and SMBP by assessing the linear relationship between measures using a linear mixed model (special case of a GLMM) with clinical BP as a continuous response measure and home BP from the corresponding day as the explanatory measure.

For the assessment of global cognition, we will use a composite z score obtained by averaging standardized z scores of individual neuropsychological test scores [50]. We will also use z scores of individual tests as outcome measures in a linear mixed model. We will again use GLMM for outcomes of MACE, ASCVD risk scores, and healthcare resource utilization. Subjects missing assessments at certain time-points will be included in all GLMMs. We will assess missingness and if missingness appears non-random, we will utilize specialized methods such as pattern mixture modeling to account for this in our GLMM inference.

To calculate feasibility, acceptability and appropriateness scores, Likert ratings will be summed and averaged across the four items. Ordinary least squares regression will be used to assess differences by health system role, awareness of vCCC, use of vCCC components, and specific intervention adaptations. For qualitative assessment of implementation outcomes, patient transcripts will be coded inductively for emerging themes and summarized to identify intervention adaptations, motivational and organizational barriers to implementation, and potential opportunities for vCCC changes. To identify relevant theoretical domains, we will use thematic coding of interview transcripts, identification of specific beliefs within coded text units, and mapping of specific beliefs onto theoretical domains. We will then map the identified constructs to behavioral needs and adaptations to the intervention. These will be used to refine the vCCC operations.

Table 4
Study outcomes.

Primary outcome	Achieving goal systolic blood pressure of <130 mmHg
Co-primary outcome	Implementation outcomes
Secondary outcomes	Cognitive function Major cardiovascular events (MACE) atherosclerotic cardiovascular disease risk (ASCVD) risk scores Health utilization All-cause mortality

4.1.1. Sample size estimation

We based our sample size calculations on a study of a similar approach [12] that found BP was controlled in 0.71 in the intervention arm versus 0.52 in the control arm. With a smaller effect size anticipated in a pragmatic trial, 400 patients post-attrition yields 71% power. Thus, we will enroll 1000 patients (500/treatment arm) to provide at least 800 patients allowing for 20% attrition (nQuery Advisor® 7.0, Elashoff 1995–2007).

5. Discussion

This study will assess the effectiveness and implementation of a remote hypertension program, logically integrating prior evidence-based approaches. While the vCCC itself has not been studied before, the individual components of the program such as SMBP, clinical pharmacist managed care, remote monitoring and management of hypertension, frequent contact with patients, patient education, and stakeholder engagement have previously shown benefit. In addition, to decrease provider workload and increase efficiency, we added automated patient identification and a BP dashboard with a traffic light system that reduces the time needed to monitor SMBP readings. Our study includes two large health systems and offers several new features, building upon the studies in the current literature to take the next step forward.

Most exploratory hypertension studies utilize the study team to lower BP. In one study with a similar SMBP approach to ours, pharmacist management of hypertension was effective in increasing the number of patients achieving BP control (72% in the intervention arm vs. 45% in usual care, $P < 0.001$). The intervention was safe and resulted in a higher BP reduction, greater medication intensification, better self-reported adherence, and higher patient satisfaction [51]. Despite this study being published in 2013, wide dissemination in routine care settings of such interventions remains lacking. The use of study team to manage hypertension left several unanswered questions about implementation of the program, such as who will manage hypertension after the study and how.

While previous studies have limitations for clinical translation of findings, they have been critical to inform the implementation focus of our study [2,52]. Publishing clinical trials and guidelines do not always lead to implementation of a strategy. Implementation studies go deeper into the need for individual behavioral change and how to achieve this change [53]. Several commercial vendors now offer remote monitoring, but effective and structured implementation of remote monitoring generally lacks consideration of implementation science and stakeholder engagement. Our study aims to enable the implementation of such remote monitoring in a way that continues to provide clinical benefit to patients.

Another unique aspect of our study is the use of EHR to identify and pre-screen patients. With widespread use of EHR in the last decade, most EHRs now have adequate data to identify patients with uncontrolled hypertension who might benefit from a program such as the vCCC. In addition to the ease of use and eliminating the need to patient identification and referral by an already busy PCP, EHR-based identification has an added advantage of limiting bias in referring patients and promoting equity in health care. Additionally, we use an opt-out approach

which enables us to include all potentially eligible patients with uncontrolled hypertension. This mimics real-world conditions, increasing the generalizability of the study. Unlike several prior studies on hypertension management which had a short duration and selective enrollment excluding patients with comorbidities such as severe kidney disease, proteinuria, recent coronary artery disease or heart failure'[51] or those on multiple anti-hypertensives, our study utilizes broad inclusion criteria. Explanatory trials often must be selective on their enrollment criteria to demonstrate efficacy while containing the study costs as broad inclusion criteria invariably increases the sample size needed.

Involvement of stakeholders at all stages of our study in another strength of the study and provides additional insights to refine the program further. The BP dashboard makes the program efficient for the vCCC pharmacists. Early feedback from the vCCC pharmacists during our pilot study [36] found that the the BP dashboard was more efficient than their current approach to managing hypertension. Currently, SMBP monitoring lacks a systematic approach. Often, patients are asked to log their BP readings and bring them to the clinic visit or enter BPs in a patient portal. From the clinic perspective, this is an additional workload, and often the personnel responsible for following these SMBPs are not clearly defined. Our program defines and streamlines the processes creating better satisfaction among patients and clinics.

We chose to include two large health systems in the study. While the study was piloted in one center with success, it is important for the vCCC program to be replicable in other health systems to achieve its full benefits in lowering BP.

The program is however tailored for large health systems with resources such as clinical pharmacists. It is also possible that some patients may miss the in-person communication with the pharmacists. The several benefits of the study however, offset these limitations. The practical integration of the vCCC into the clinical workflow without adding burden to the already busy PCPs is a major strength of the study.

In conclusion, this hybrid implementation effectiveness pragmatic study may be next step to implement evidence-based strategies and hypertension guidelines in the form of a virtual hypertension program that can run across health systems. While prior studies have shown us 'what' to do (i.e., lower BP), this study will demonstrate 'how' to lower BP in the real world.

Data sharing

The study team will share data per NIH regulations. Findings from the study will be published in peer review journals.

Author contributions

Aditi Gupta: Secured funding and drafted the protocol and manuscript.

Hira Chouhdry: Wrote the first draft of the manuscript.

Shellie D Ellis: Drafted implementation sections and critically reviewed the manuscript.

Kate Young and Jonathan Mahnken: Drafted the statistical analysis sections of the manuscript.

Branden Comfort, Denton Shanks, Sheila McGreevy, Courtney Rudy, Tahira Zufer, Sharissa Mabry, Jennifer Woodward: Critically reviewed the protocol and manuscript.

Amber Wilson, Heidi Anderson: Drafted the protocol and critically reviewed the manuscript.

Jennifer Loucks and Nolan Schmitz: Critically reviewed the protocol and manuscript with focus on the intervention.

Sravani Chandaka, Noor Abu-el-rub, Diego R Mazzotti, Xing Song: Critically reviewed the protocol and manuscript with focus on data collection, management, and analysis.

Molly Conroy and Mark A. Supiano: Critically reviewed the protocol and manuscript.

Lemuel R Waitman and Jeffrey M Burns: Secured funding and critically reviewed the protocol and manuscript.

CRediT authorship contribution statement

Aditi Gupta: Writing – review & editing, Writing – original draft, Visualization, Supervision, Methodology, Funding acquisition, Conceptualization. **Hira Chouhdry:** Writing – original draft. **Shellie D. Ellis:** Writing – review & editing, Writing – original draft, Methodology, Conceptualization. **Kate Young:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis. **Jonathan Mahnken:** Writing – review & editing, Methodology, Conceptualization. **Branden Comfort:** Writing – review & editing. **Denton Shanks:** Writing – review & editing. **Sheila McGreevy:** Writing – review & editing. **Courtney Rudy:** Writing – review & editing. **Tahira Zufer:** Writing – review & editing. **Sharissa Mabry:** Writing – review & editing. **Jennifer Woodward:** Writing – review & editing. **Amber Wilson:** Writing – review & editing. **Heidi Anderson:** Writing – review & editing. **Jennifer Loucks:** Writing – review & editing, Methodology. **Sravani Chandaka:** Writing – review & editing. **Noor Abu-el-rub:** Writing – review & editing. **Diego R. Mazzotti:** Writing – review & editing, Methodology. **Xing Song:** Writing – review & editing, Writing – original draft, Methodology. **Nolan Schmitz:** Writing – review & editing, Methodology. **Molly Conroy:** Writing – review & editing. **Mark A. Supiano:** Writing – review & editing. **Lemuel R. Waitman:** Writing – review & editing, Methodology. **Jeffrey M. Burns:** Writing – review & editing, Conceptualization.

Declaration of competing interest

None of the authors have financial or other conflict of interest with the study.

Data availability

Data will be made available on request.

Acknowledgements

This work was funded by NIA award R61/R33 AG068483.

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