Journal of the American Heart Association

ORIGINAL RESEARCH

Feasibility and Short-Term Effects of a Multi-Component Emergency Department Blood Pressure Intervention: A Pilot Randomized Trial

Andrew J. Spieker [iD], PhD; Lyndsay A. Nelson [iD], PhD; Russell L. Rothman [iD], MD, MPP; Christianne L. Roumie [iD], MD, MPH; Sunil Kripalani, MD, MSc; Joseph Coco [iD], MS; Daniel Fabbri, PhD; Phillip Levy [iD], MD, MPH; Sean P. Collins, MD, MSc; Tommy Wang [iD], MD; Dandan Liu [iD], PhD; Candace D. McNaughton [iD], MPH, MD, PhD

BACKGROUND: Emergency department (ED) visits can be opportunities to address uncontrolled hypertension. We sought to compare short-term blood pressure measures between the Vanderbilt Emergency Room Bundle (VERB) intervention and usual care plus education.

METHODS AND RESULTS: We conducted a randomized trial of 206 adult patients with hypertension and elevated systolic blood pressure (SBP) presenting to 2 urban emergency departments in Tennessee, USA. The VERB intervention included educational materials, a brief motivational interview, pillbox, primary care engagement letter, pharmacy resources, and 45 days of informational and reminder text messages. The education arm received a hypertension pamphlet. After 78 participants were enrolled, text messages requested confirmation of receipt. The primary clinical outcome was 30-day SBP. The median 30-day SBP was 122 and 126 mm Hg in the VERB and education arms, respectively. We estimated the mean 30-day SBP to be 3.98 mm Hg lower in the VERB arm (95% CI, −2.44 to 10.4; P=0.22). Among participants enrolled after text messages were adapted, the respective median SBPs were 121 and 130 mm Hg, and we estimated the mean 30-day SBP to be 8.57 mm Hg lower in the VERB arm (95% CI, 0.98−16.2; P=0.027). In this subgroup, the median response rate to VERB text messages was 56% (interquartile range, [26%−80%]).

CONCLUSIONS: This pilot study demonstrated feasibility and found an improvement in SBP for the subgroup for whom interactive messages were featured. Future studies should evaluate the role of interactive text messaging as part of a comprehensive emergency department intervention to improve blood pressure control.

REGISTRATION: URL: https://www.clinicaltrials.gov; Unique identifier: NCT02672787.

Key Words: emergency care ■ hypertension ■ medication adherence ■ motivational interviewing ■ patient engagement

O ver 45% of American adults have hypertension, and prevalence continues to rise.[1,2] Treatment of hypertension reduces risk of subsequent cardiovascular, kidney, and cerebrovascular disease.[3] Elevated blood pressure (BP) is common among patients seeking care in the emergency department (ED), and ED visits related to hypertension increased by 25% between 2006 and 2012.[4] Current guidelines recommend clinicians inform patients with elevated ED BP about related risks and discuss lifestyle

CLINICAL PERSPECTIVE

What Is New?

- This study assesses feasibility and short-term efficacy of a multi-component intervention (Vanderbilt Emergency Room Bundle) for management of hypertension in the emergency department setting.
- The intervention included educational materials, a motivational interview, pillbox, primary care engagement letter, pharmacy resources, and 45 days of informational and reminder text messages.
- Implementation of Vanderbilt Emergency Room Bundle took only 12 minutes longer than usual care, on average; a subset of Vanderbilt Emergency Room Bundle participants were eligible to receive requests for confirmation of text message receipt, among whom there is evidence of efficacy.

What Are the Clinical Implications?

- Our study suggests that a multi-component intervention to support hypertension management is feasible for implementation in the emergency department setting and may provide at least short-term benefit.
- Allowing patients to engage with text message delivered interventions may be essential for them to derive benefit from them.
- Further work should be done to assess the scalability of this intervention in a wider array of settings.

Non-Standard Abbreviations and Acronyms

RA	research assistant
VERB	Vanderbilt Emergency Room Bundle

changes as well as follow-up,[5–7] though implementation varies.[8]

ED visits can be viewed as opportunities to identify patients at risk for poor control of chronic conditions such as hypertension and related adverse health outcomes such as stroke or heart failure.[9–12] In primary care settings, successful chronic disease management interventions often address multiple determinants of health behavior simultaneously.[13,14] While several ED-based intervention bundles have been developed for other conditions such as substance use disorders, few have specifically targeted hypertension self-management.[15–17] In one recent pilot trial, a multicomponent intervention that provided education

and support as part of an ED visit led to improved BP among racial and ethnic minorities.[18] However, more work is needed to identify which and how interventions are effective in improving hypertension control during the transition from ED care to primary care.

The Vanderbilt Emergency Room Bundle (VERB) intervention was developed based on successful medication adherence and hypertension clinic-based interventions and included motivational interviewing, an educational toolkit, a pill box, and other activities during the ED encounter.[19–22] VERB also included tailored text messages for 45 days after ED discharge. We conducted a pilot randomized trial to evaluate the feasibility of the VERB intervention and evaluate its short-term effects on BP control and medication adherence relative to a control arm that included basic education materials on hypertension.

METHODS

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Study Setting and Population

Participants were enrolled in the Adult EDs at Vanderbilt University Medical Center and the Veterans Health Administration Tennessee Valley Healthcare System in Nashville, TN, USA between February 25, 2016 and January 15, 2018. Inclusion criteria were: (1) age 21 to 84 years (at the time of the study, the National Institutes of Health defined adult as ≥21 years of age, and patients of age ≥85 years were excluded because of concerns of safety in a more frail population), (2) an established primary care provider with a clinic visit within the previous 365 days, (3) at least 1 antihypertensive medication prescription, (4) first systolic blood pressure (SBP) measured upon ED arrival of at least 140 mm Hg measured during routine care, (5) anticipated discharge from the ED, (6) willingness and ability to receive text messages and return for follow-up visits, (7) enrollment within 6 hours of initial ED evaluation, and (8) able to read and understand English. Patients were ineligible if they were receiving hemodialysis, had symptoms preventing oral intake or affecting BP (eg, vomiting, acute alcohol withdrawal, known pregnancy), or had received vasoactive or anti-hypertensive medication in between ED presentation and enrollment.

Study Procedures

The institutional review boards at both sites approved all study procedures. Study participants provided written informed consent and could earn up to $50 for completing the study (but were not compensated for receiving or responding to text messages). Research

assistants (RAs) conducted initial screening via electronic whiteboards, and additional screening in person, immediately before approach for potential enrollment. Baseline data were recorded on paper and entered in Research Electronic Data Capture[23] and included demographics (sex, race, education, income, and insurance) and validated measures of health literacy, numeracy, and perceived health competence.[24–26]

Participants were randomized in a 1:1 fashion to VERB or an education control. Randomization was conducted using the 'blockrand' package in R with variable block sizes, and was stratified by sex (men, women), race (White or non-White), number of prescribed BP medications (1 or >1), and study site. Further details about the selection of variable/permuted block sizes are presented in Data S1.

Study Arms: Education and VERB Intervention Bundle

Immediately following randomization, participants assigned to the comparison arm were provided educational materials about hypertension published by the National Institutes of Health.[27] No specific effort was made to review these materials unless participants had specific questions. For participants randomized to VERB, a trained RA administered the following intervention components immediately after randomization and before ED discharge in the following approximate order: (1) an educational toolkit developed from materials designed for racially and socioeconomically diverse populations and adapted to hypertension and the ED setting through an iterative process of patient interviews and feedback from experts in health communication and health literacy (see Data S2 for further details)[28–33]; (2) a brief motivational interview, which was recorded and scored by a motivational interview trainer; feedback was provided to individual RAs to ensure fidelity;[34–36] (3) a pill box; and (4) pharmacy resources for those participants who noted barriers to medication adherence. A tailored engagement letter was sent to the participant's primary care provider after the ED visit; a health goal was included in the letter if identified during the motivational interview. The final VERB intervention component was text messages for 45 days following discharge. Each participant could choose to receive medication reminders ("Hello from your VERB Team: Have you taken your medicine today?") and/or information about hypertension and medication adherence (Data S3), along with the time of day and frequency of text messages (once or twice daily for reminders, and every 3 days or once weekly for informational messages). Participants were given a relatively wide range of text message options to assess the frequency and range of preferences to guide future patient engagement interventions. Information about

patient preferences for text messages are reported by Nelson et al.[37] A welcome text was sent before ED discharge to ensure successful receipt, and a concluding message was sent at 45 days, after which the text message component of the intervention ceased.

After January 4, 2017, the text message platform was adapted such that all messages were followed by a request for confirmation ("Reply with 'Y' to let us know you got this message. Thank you!"). Responses including "yes," "yeah," "yep," "1," and "si" were registered by the text messaging platform as acceptable responses; non-acceptable responses received a follow-up text message reading "Sorry, we didn't understand that…could you respond with 'Y' or '1' to let us know you received the message?" Participants could opt out of text messages by texting "STOP."

Feasibility Assessment

Because the ED has been perceived as a potentially suboptimal environment in which to conduct behavioral interventions, combined with resistance to management of chronic conditions in the ED setting, we also assessed the feasibility of the intervention bundle in various ways.[5,6,38] We evaluated time spent by RAs on study procedures with the patient in the ED (consent, data collection, and delivery of intervention). In addition, we examined text message engagement among participants randomized to the VERB intervention after text messages were adapted to include requests for confirmation. Specifically, we define engagement as the participant-specific response rate (the proportion of messages sent receiving a confirmation). Response rates were aggregated over days 6 through 45, allowing a brief run-in/acclimation period. When participants opted out of text messages, we marked them as being non-responsive for the remainder of the 45-day period. We further asked participants in the VERB arm to indicate whether they would recommend text messages to family or friends.

Clinical Outcomes

In-person follow-up visits were targeted for 30 and 90 days after discharge. RAs conducting assessments were masked to study arm allocation. Efforts were made to meet participants at clinic visits to improve study retention. Participants who declined in-person follow-up were given the option to complete the self-reported assessments by phone. The primary clinical outcome was 30-day SBP, a timeframe chosen to allow possible intervention effects to be reflected in SBP. Enrollment and follow-up BP was measured using BpTRU, which uses the oscillatory method based on the mean of 6 BP measurements at 1-minute intervals and has been shown to reflect ambulatory BP.[39] The patient was seated with 5 minutes

of rest before obtaining the BP measure. Secondary outcomes included 90-day SBP, 30- and 90-day diastolic BP (DBP), and 30- and 90-day patient-reported medication adherence, as assessed by the validated 7-item Adherence to Refills and Medications Scale.[40]

Statistical Analysis

In the interest of full transparency, we report the a priori sample size target and its component assumptions, although 220 of the originally planned 350 participants were enrolled within the funded timeframe. Sample size calculations were designed based on difference in mean 30-day SBP as the outcome; 350 participants would provide 80% power to detect an effect size of 0.32 SDs based on a level of $\alpha=0.05$ and 10% attrition.

Analyses were conducted in R, version 4.0.3.[41] We report descriptive statistics as medians and interquartiles for continuous variables and as absolute and relative frequencies for discrete variables. Statistical significance was considered achieved at a threshold of $P<0.05$. To address missing data, we used multiple imputation via chained equations with 500 iterations.[42,43]

In our feasibility assessment, we used linear regression to compare mean time spent with participants between treatment arms. We computed descriptive statistics for text message response rates among participants assigned to the VERB intervention following inclusion of interactive text messages.

To accommodate repeated outcome measures on patients over time, we used generalized estimating equations with an identity link and a working independence correlation structure[44] to compare mean SBP between study arms. To increase precision of estimation, we adjusted for study site, number of prescribed BP medications, and enrollment SBP (as a restricted cubic spline with knots at the interior quartiles of 124, 134, and 152 mm Hg). To reflect variability in follow-up times, we modeled the effect of VERB over time continuously using a restricted cubic spline on time with an intervention-time interaction (knots were placed at the first through fourth quintiles: 29, 38, 82, and 92 days); 95% CIs were obtained for the pre-specified times of 30 (primary) and 90 days (secondary). Analogous generalized estimating equations were used for the secondary outcomes of DBP (with knots at 78, 85, and 96 mm Hg for baseline DBP) and medication adherence (with knots at 8, 11, and 14 for baseline 7-item Adherence to Refills and Medications Scale). For our primary analyses, we further conducted subgroup analyses by sex and race.

To better understand the role of text message engagement on outcomes, we conducted a subgroup analysis restricted to participants enrolled after interactive text messages became available.

RESULTS

Between February 2016 and January 2018, 16 143 patients in ED were screened and 12 833 were excluded through electronic chart review. An additional 3090 were excluded after additional discussion with the patient or their clinician, of which 510 (15.4%) declined after they were approached in person. Enrollment was halted after 220 patients were randomized because of resource constraints, 14 of whom were later identified as not having met inclusion criteria and thus not included in our analyses (Figure 1).

Participant Characteristics

The median age was 51 years, 57.3% were women, and 46.1% were Black. Self-reported education level was high, with a median of 14 years of schooling. The majority (56.8%) were prescribed >1 antihypertensive medication, and 58.3% of participants reported having a BP monitor at home (Table 1).

Analysis of Feasibility

RAs recorded time spent on research procedures for 98 of 105 (93%) of control participants and 96 of 101 (95%) of VERB participants. The distribution of time spent was highly variable (Figure S1). The median time (in minutes) spent with participants was 45 for the control arm (interquartile range [IQR], [40–50]) and 60 for the VERB arm (IQR, 4565). The estimated mean time spent was 11.7 minutes longer for participants assigned to the VERB intervention (95% CI, 5.73–17.6; $P<0.001$).

Four VERB participants, 3.9% requested termination of text messages before the pre-specified time of 45 days. After the 90-day follow-up, 54 of101 (53.4%) indicated that they would recommend text messages to family or friends.

Among the 63 VERB participants enrolled after interactive text messages were available, the response rate was heterogeneous (Figure S2). The mean message response rate was 53% (SD, 32%); the median response rate was 56% (IQR, 26%–80%). A total of 7 of 63 (11%) responded to at least 90% of the text messages, while 11 of 63 (18%) confirmed receipt of <10% of text messages.

Analysis of Clinical Outcomes

Overall, 150 (72.8%) completed at least 1 follow-up visit, (131 [63.6%] completing a 30-day visit, 126 [61.2%] completing a 90-day visit, and 107 [51.9%] completing both). Two patients completed 30-day follow-up and 3 patients completed 90-day follow-up by phone; BP measurements were missing for these 5 individuals as they did not have BP monitors at home. The distribution of follow-up times is shown in Figure S3.

Follow-up BP was largely well-controlled in both arms (Table 2), with a median 30-day SBP of 122 mm Hg
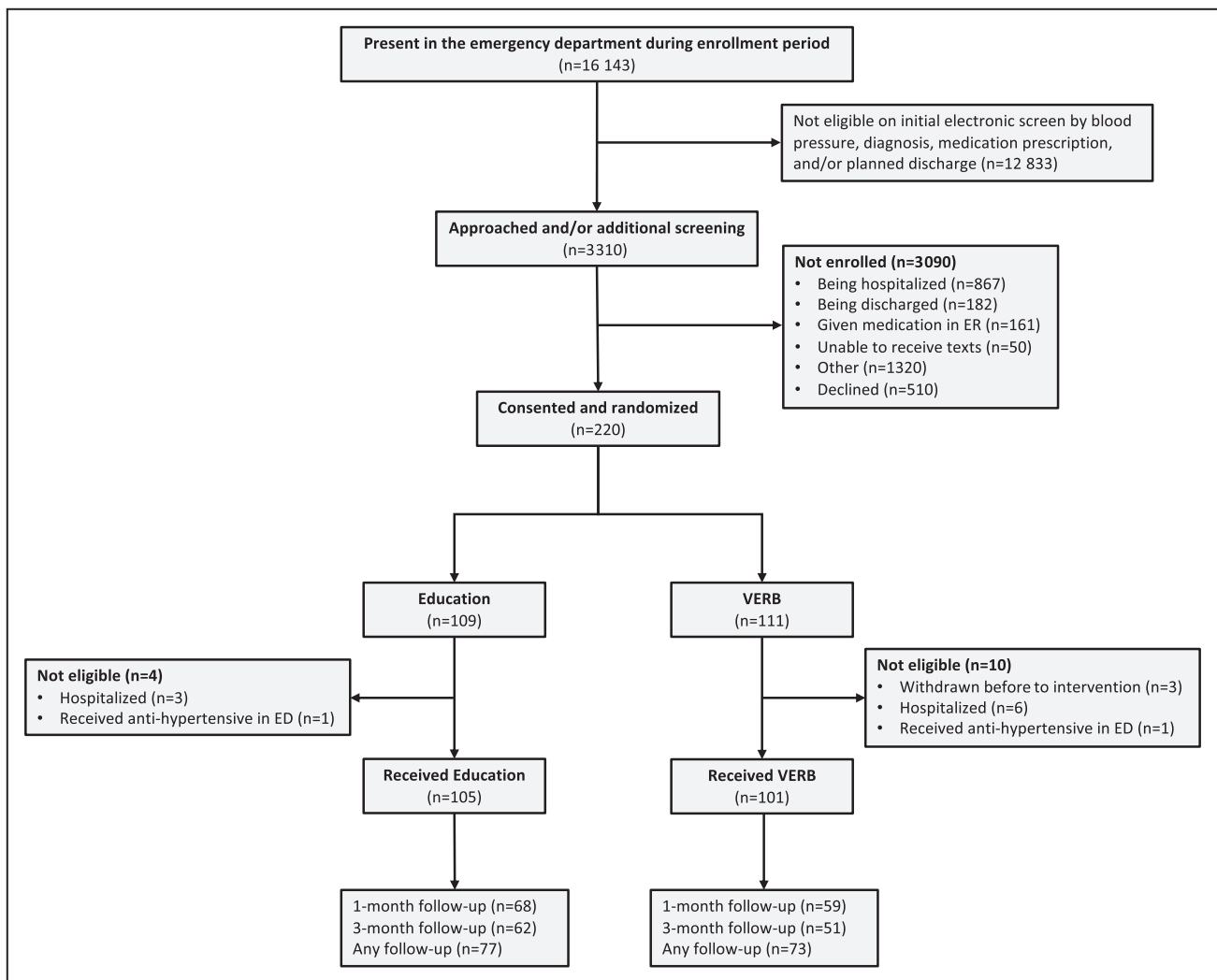
Figure 1. Flow diagram of subject disposition and enrollment.
ED indicates emergency department; ER, emergency room; and VERB, Vanderbilt Emergency Room Bundle.

(IQR, 113–135) for the VERB arm and 126 mm Hg (IQR, 117–140) for the control arm, reflecting reductions of 14 and 5 mm Hg from baseline, respectively. There were no statistically significant differences in mean follow-up SBP, DBP, or adherence between arms in the full cohort (Table 3). We estimated an adjusted mean difference in 30-day SBP of −3.98 mm Hg (95% CI, −10.4 to 2.44; P=0.22). Figure 2A and 2B depicts point estimates and 95% confidence bands on adjusted mean differences for BP over time. No sex-specific or race-specific differences were noted.

Subgroup Analysis

A total of 128 participants were enrolled after text messages requested confirmation of receipt (63 randomized to VERB, and 65 to education; descriptive statistics shown in Table S1). In this subgroup, the median 30-day SBP was 121 mm Hg in the VERB arm (IQR, 110–128)

and 130 mm Hg in the education control arm (IQR, 122–145). The adjusted mean difference was estimated as −8.57 mm Hg (95% CI, −16.2 to −0.98; P=0.027). The median DBP was 77 mm Hg in the VERB arm (IQR, 71–86) and 83 mm Hg in the education control arm (IQR, 76–91). The adjusted mean difference was estimated as −4.69 mm Hg (95% CI, 0.21–9.17; P=0.040]). We did not identify statistically significant differences in 90-day BP (45 days following the conclusion of text messages; Table 4), or in medication adherence at either pre-specified follow-up time. Figure 2C and 2D depicts point estimates and 95% confidence bands on adjusted mean differences in BP over time for this subgroup.

DISCUSSION

Between 10% and 30% of patients in the United States seek ED care each year,[45] making the ED a common access point into the healthcare system.

Table 1. Participant Demographics

	Total (n=206)	Education (n=105)	VERB (n=101)
Age, y	51 (42, 60)	49 (41, 58)	53 (43, 62)
Women, n (%)	118/206 (57.3)	60/105 (57.1)	58/101 (57.4)
Race, n (%)			
White	101/206 (49.0)	48/105 (45.7)	53/101 (52.5)
Black	95/206 (46.1)	52/105 (49.5)	43/101 (42.6)
Other*	10/206 (4.9)	5/105 (4.8)	5/101 (5.0)
Prescribed BP medications			
1, n (%)	89 (43.2)	45 (42.9)	44 (43.6)
>1, n (%)	117 (56.8)	60 (57.1)	57 (56.4)
Health insurance, n (%)			
Private	104/203 (51.2)	54/103 (52.4)	50/100 (50.0)
Government Insurance	77/203 (37.9)	33/103 (32.0)	44/100 (44.0)
Uninsured/ Self/Unknown	17/203 (8.4)	12/103 (11.7)	5/100 (5.0)
Work-related injury	5/203 (2.5)	4/103 (3.9)	1/100 (1.0)
Total education, y	14 (12, 16)	14 (12, 16)	14 (12, 16)
Household income ($ × 1000)	36.6 (19.6, 750)	36.1 (18.0, 70.0)	39.6 (20.0, 75.0)
Diabetes, n (%)	56/205 (27.3)	26/104 (25.0)	30/101 (29.7)
BP monitor at home, n (%)	120/206 (58.3)	64/105 (61.0)	56/101 (55.4)
Enrollment SBP, mm Hg	134 (124, 152)	131 (123, 145.5)	136 (127, 155)
Enrollment DBP, mm Hg	85 (78, 96)	84.5 (77, 95.5)	86 (78, 96)
Enrollment ARMS-7	9 (8, 12)	9 (8, 12)	9 (8, 12)
BHLS	14 (12, 15)	14 (12, 15)	15 (12, 15)
SNS	14 (10, 16)	14 (10, 17)	14 (10, 16)
PHQ-2	1 (0, 3)	1 (0, 3)	1 (0, 3)
PHCS-2	8 (6, 10)	8 (7, 10)	8 (6, 9)
GTH	33 (27, 37)	32 (26.5, 37.5)	33 (27, 36.5)
Enrollment site, n (%)			
VUMC	189/206 (91.8)	96/105 (91.4)	93/101 (92.1)
VHA	17/206 (8.3)	9/105 (8.6)	8/101 (7.9)

Continuous values are reported as medians, with first and third quartiles; discrete variables are reported as absolute and relative frequencies.

ARMS-7 indicates 7-item Adherence to Refills and Medications Scale; BHLS, brief health literacy survey; BP, blood pressure; DBP, diastolic blood pressure; GTH, global total health; PHCS-2, 2-item Perceived Health Competence Scale; PHQ-2, 2-item Personal Health Questionnaire; SBP, systolic blood pressure; SNS, subjective numeracy scale; VERB, Vanderbilt Emergency Room Bundle; VHA, Veterans Health Administration; and VUMC, Vanderbilt University Medical Center.

*Other: Asian, American Indian/Alaska Native, Native Hawaiian, Other Pacific Islander, more than one race, or unknown.

Consistently elevated ED BP is a strong predictor of subsequent uncontrolled hypertension.[46,47] Despite great strides, hypertension remains one of the most potent, common, and modifiable underlying causes of

Table 2. Distribution of Clinical Outcomes in Each Arm

	Education (n=105)	VERB (n=101)
SBP, mm Hg		
30-d SBP, mm Hg; n=127	126 (117, 140)	122 (113, 135)
90-d SBP, mm Hg; n=113	122 (117, 138)	121 (115, 132)
DBP, mm Hg		
30-d; n=127	83 (74, 91)	80 (72, 87)
90-d; n=113	81 (74, 90)	80 (73, 85)
ARMS-7		
30-d; n=127	9 (7, 11)	9 (7, 11)
90-d; n=113	9 (7, 11)	9 (7, 11)

Reported as median (first and third quartiles).

ARMS-7 indicates 7-item Adherence to Refills and Medications Scale; DBP, diastolic blood pressure; SBP, systolic blood pressure; and VERB, Vanderbilt Emergency Room Bundle.

stroke, cardiovascular disease, and renal failure.[3] ED visits for patients with elevated BP or hypertension-related complaints may serve as healthcare touch points to impact chronic disease management by complementing chronic care.[48–51] We conducted a pilot-randomized trial to determine the feasibility of an ED-based BP intervention bundle and evaluate its effects on short-term BP and patient-reported medication adherence.

The VERB intervention demonstrated feasibility in a number of ways. The key components of the VERB intervention can be delivered to participants by individuals without extensive medical training. On average, the time spent with VERB participants by RAs was only 11.7 minutes longer as compared with the education arm. Further, response to confirmation requests serves as a proxy for engagement with messages and demonstrated fidelity to the VERB intervention; over half of VERB participants indicated that they would recommend text messages to a friend or family member.

Table 3. Point Estimates and 95% CIs for Mean Differences in Blood Pressure and Patient-Reported Adherence, Comparing the VERB Intervention to an Education Intervention at 30 and 90 Days

Outcome	30 d		90 d	
	Estimate [95% CI]	P value	Estimate [95% CI]	P value
SBP, mm Hg	−3.98 [−10.4 to 2.44]	0.22	−1.37 [−8.17 to 5.54]	0.69
DBP, mm Hg	−3.00 [−6.73 to 0.72]	0.11	−2.28 [−5.95 to 1.38]	0.22
ARMS-7	−0.30 [−0.92 to 0.33]	0.35	−0.34 [−1.19 to 0.51]	0.43

ARMS-7 indicates 7-item Adherence to Refills and Medications Scale; DBP, diastolic blood pressure; SBP, systolic blood pressure; and VERB, Vanderbilt Emergency Room Bundle.
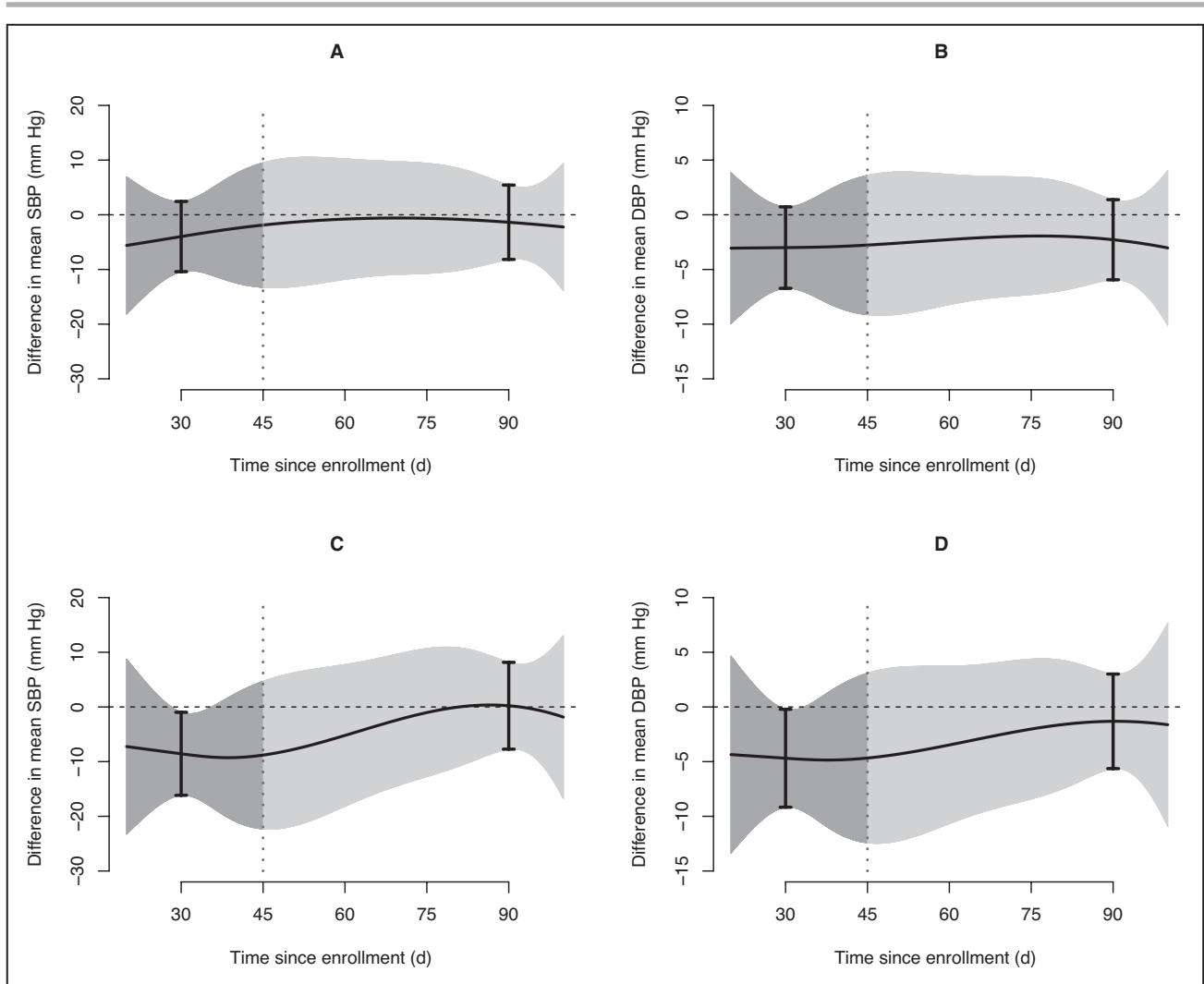
Figure 2. Adjusted treatment effect estimates over time.
A and **B**, The estimated adjusted mean difference in follow-up systolic and diastolic blood pressure (mm Hg) comparing the Vanderbilt Emergency Room Bundle intervention against the education intervention, over time post-enrollment; included are corresponding pointwise 95% confidence bands. **C** and **D**, The analogous results, restricted to participants enrolled after interactive text messaging was available. Text messages continued for 45 days post-enrollment, as indicated by the vertical dashed line and darker shading in all panels. DBP indicates diastolic blood pressure; and SBP, systolic blood pressure.

Apart from random variation, several mechanisms could plausibly explain why the VERB intervention would benefit from the inclusion of interactive text messaging. All VERB participants were able to choose the type, frequency, and timing of their text messages with the goal of empowering patients to match the appropriate "dose" of text messages to their specific needs. Interactive text messages requesting confirmation of receipt (but, in particular, not a response on medication adherence itself) may have provided a sufficient engagement opportunity and motivate behavioral change without causing "alarm fatigue."[52,53] Of note, the estimated magnitude of benefit from the VERB intervention in the subgroup receiving confirmation requests closely mirrors that which would be expected from adherence to 1 additional antihypertensive medication.[54] Text messages may have increased patient engagement in hypertension control or improved medication adherence, perhaps to a degree and over a timeframe not detected by the 7-item Adherence to Refills and Medications Scale.

While ED-based multi-component interventions have been successful with other chronic diseases,[55–57] they are often resource-intensive and can be difficult to implement, scale, and sustain. On the other hand, education alone is rarely sufficient to generate lasting behavioral change,[58–60] hence motivating our choice to allow a component of VERB to continue beyond the ED visit. Of note, this trial is not adequately powered to isolate the effect of interactive text messages absent the other components of the VERB intervention; however, our results warrant further examination of text

Table 4.   Point Estimates and 95% CIs for Mean Differences in Blood Pressure and Patient-Reported Adherence, Comparing the Verb Intervention to an Education Intervention at 30 and 90 Days Among Participants Enrolled After Interactive Text Messages Were Available

Outcome	30 d		90 d	
	Estimate [95% CI]	*P* value	Estimate [95% CI]	*P* value
SBP, mm Hg	−8.57 [−16.2 to −0.98]	0.027	0.72 [−7.72 to 8.16]	0.96
DBP, mm Hg	−4.69 [−9.17 to −0.21]	0.040	−1.32 [−5.64 to 3.01]	0.55
ARMS-7	−0.02 [−0.75 to 0.72]	0.97	−0.14 [−1.13 to 0.85]	0.78

ARMS-7 indicates 7-item Adherence to Refills and Medications Scale; DBP, diastolic blood pressure; and SBP, systolic blood pressure.

messages to improve BP control. If text messages alone are sufficient, this allows for a more scalable and cost-effective approach to intervene relative to a bundled, multi-component intervention. Other studies have demonstrated the feasibility of using text messages to improve blood pressure by recruiting patients from the ED setting,[61,62] but more long-term, rigorous trials are needed to determine the impact on patient outcomes. In particular, it will be important for future trials to measure sustainability of effects; in our study the estimated treatment effect attenuated quickly following completion of the text-message component of VERB. This finding is consistent with prior studies of text message interventions in other disease contexts, which were unable to show durability of effects following completion of the text messages.[63]

Limitations

Despite requiring elevated SBP for inclusion at time of presentation, SBP measured by research staff at study enrollment was well-controlled for many participants. This may be explained in part by regression to the mean and may have attenuated the relative effect of VERB toward the null. An observed decrease in 30-day BP in both arms may further reflect a combination of the intervention's effect and additional regression to the mean. This ED-based intervention focused on patients with hypertension who were prescribed at least 1 antihypertensive medication at the time of their ED visit. Future studies may seek to determine whether these findings generalize to similar patients after a brief hospitalization or who are on >1 antihypertensive medication. In addition, we had to stop enrollment after randomizing 220 participants because of resource constraints, which prevented us from meeting our recruitment goal; although this may have restricted power, we were still able to detect effects

in our subgroup analysis. Similarly, variation in follow-up time reduced our power to detect effects at pre-specified time points but allowed us to estimate the effects continuously over time and leverage the fact that many patients had follow-up within 2 weeks of the text message cessation time of 45 days. Overall, 72.8% of participants completed at least 1 in-person follow-up. Use of multiple imputation allowed us to leverage all evaluable participants, including data from participants with incomplete follow-up data.

CONCLUSIONS

As the prevalence of uncontrolled hypertension continues to rise, opportunities to address elevated BP should be leveraged. The VERB intervention warrants further evaluation as a scalable means of engaging patients in ED on hypertension control while they safely make the transition back to primary care for long-term management. Although effects were small, individual incremental improvements in adherence, self-care, or blood pressure have important implications on a population level.[64,65] An interactive text messaging intervention in the ED is a promising approach for identifying and engaging with otherwise difficult-to-reach or high-risk patients.

Supplemental Material

Data S1–S3
Table S1
Figures S1–S3

REFERENCES

1. Virani SS, Alonso A, Benjamin EJ, Bittencourt MS, Callaway CW, Carson AP, Chamberlain AM, Chang AR, Cheng S, Delling FN, et al. Heart disease and stroke statistics-2020 update: a report from the American Heart Association. *Circulation*. 2020;141:e139–e596. doi: 10.1161/CIR.0000000000000757

2. Curfman G, Bauchner H, Greenland P. Treatment and control of hypertension in 2020: the need for substantial improvement. *JAMA*. 2020;324:1166–1167. doi: 10.1001/jama.2020.13322

3. Adams JM, Wright JS. A National commitment to improve the care of patients with hypertension in the US. *JAMA*. 2020;324:1825–1826. doi: 10.1001/jama.2020.20356

4. McNaughton CD, Self WH, Zhu Y, Janke AT, Storrow AB, Levy P. Incidence of hypertension-related emergency department visits in the United States, 2006 to 2012. *Am J Cardiol*. 2015;116:1717–1723. doi: 10.1016/j.amjcard.2015.09.007

5. Brody A, Twiner M, Kumar A, Goldberg E, McNaughton C, Souffront K, Millis S, Levy PD. Survey of emergency physician approaches to management of asymptomatic hypertension. *J Clin Hypertens*. 2017;19:265–269. doi: 10.1111/jch.12921

6. Brody A, Janke A, Sharma V, Levy P. Public health, hypertension, and the emergency department. *Curr Hypertens Rep*. 2016;18:50. doi: 10.1007/s11906-016-0654-5

7. Wolf SJ, Lo B, Shih RD, Smith MD, Fesmire FM. Clinical policy: critical issues in the evaluation and management of adult patients in the emergency department with asymptomatic elevated blood pressure. *Ann Emerg Med*. 2013;62:59–68. doi: 10.1016/j.annemergmed.2013.05.012

8. Levy PD. Whose job is it anyway? *Acad Emerg Med*. 2019;26:584–586. doi: 10.1111/acem.13762

9. Ovbiagele B. The emergency department: first line of defense in preventing secondary stroke. *Acad Emerg Med*. 2006;13:215–222. doi: 10.1197/j.aem.2005.07.035

10. Carrier E, Tracy Y, R. H. Coordination Between Emergency and Primary Care Physicians. National Institute for Health Care Reform Research Brief. Vol 3. 2011.

11. Doran KM, Raven MC, Rosenheck RA. What drives frequent emergency department use in an integrated health system? National data from the veterans health administration. *Ann Emerg Med*. 2013;62:151–159. doi: 10.1016/j.annemergmed.2013.02.016

12. Overgaauw N, Alsma J, Brink A, Hameli E, Bahmany S, Peeters LEJ, Van Den Meiracker AH, Schuit SCE, Koch BCP, Versmissen J. Drug nonadherence is a common but often overlooked cause of hypertensive urgency and emergency at the emergency department. *J Hypertens*. 2019;37:1048–1057. doi: 10.1097/HJH.0000000000002005

13. Wald DS, Bestwick JP, Raiman L, Brendell R, Wald NJ. Randomised trial of text messaging on adherence to cardiovascular preventive treatment (INTERACT trial). *PLoS One*. 2014;9:e114268. doi: 10.1371/journal.pone.0114268

14. Peacock E, Krousel-Wood M. Adherence to antihypertensive therapy. *Med Clin North Am*. 2017;101:229–245. doi: 10.1016/j.mcna.2016.08.005

15. Zafar MA, Loftus TM, Palmer JP, Phillips M, Ko J, Ward SR, Foertsch M, Dalhover A, Doers ME, Mueller EW, et al. COPD care bundle in emergency department observation unit reduces emergency department revisits. *Respir Care*. 2020;65:1–10. doi: 10.4187/respcare.07088

16. Freund Y, Cachanado M, Delannoy Q, Laribi S, Yordanov Y, Gorlicki J, Chouihed T, Féral-Pierssens A-L, Truchot J, Desmettre T, et al. Effect of an emergency department care bundle on 30-day hospital discharge and survival among elderly patients with acute heart failure: the ELISABETH randomized clinical trial. *JAMA*. 2020;324:1948–1956. doi: 10.1001/jama.2020.19378

17. Tromp M, Hulscher M, Bleeker-Rovers CP, Peters L, van den Berg DT, Borm GF, Kullberg BJ, van Achterberg T, Pickkers P. The role of nurses in the recognition and treatment of patients with sepsis in the emergency department: a prospective before-and-after intervention study. *Int J Nurs Stud*. 2010;47:1464–1473. doi: 10.1016/j.ijnurstu.2010.04.007

18. Prendergast H, Del Rios M, Durazo-Arvizu R, Escobar-Schulz S, Heinert S, Jackson M, Gimbar RP, Daviglus M, Lara B, Khosla S. Effect of an emergency department education and empowerment intervention on uncontrolled hypertension in a predominately minority population: the AHEAD2 randomized clinical pilot trial. *J Am Coll Emerg Physicians Open*. 2021;2:e12386. doi: 10.1002/emp2.12386

19. White RO, Eden S, Wallston KA, Kripalani S, Barto S, Shintani A, Rothman RL. Health communication, self-care, and treatment satisfaction among low-income diabetes patients in a public health setting. *Patient Educ Couns*. 2015;98:144–149. doi: 10.1016/j.pec.2014.10.019

20. Roumie CL, Greevy R, Wallston KA, Elasy TA, Kaltenbach L, Kotter K, Dittus RS, Speroff T. Patient centered primary care is associated with patient hypertension medication adherence. *J Behav Med*. 2011;34:244–253. doi: 10.1007/s10865-010-9304-6

21. Gwadry-Sridhar FH, Manias E, Lal L, Salas M, Hughes DA, Ratzki-Leewing A, Grubisic M. Impact of interventions on medication adherence and blood pressure control in patients with essential hypertension: a systematic review by the ISPOR medication adherence and persistence special interest group. *Value Health*. 2013;16:863–871. doi: 10.1016/j.jval.2013.03.1631

22. Hedegaard U, Kjeldsen LJ, Pottegard A, Henriksen JE, Lambrechtsen J, Hangaard J, Hallas J. Improving medication adherence in patients with hypertension: a randomized trial. *Am J Med*. 2015;128:1351–1361. doi: 10.1016/j.amjmed.2015.08.011

23. Harris PA. Research Electronic Data Capture (REDCap)-planning, collecting and managing data for clinical and translational research. *BMC Bioinform*. 2012;13:A15. doi: 10.1186/1471-2105-13-S12-A15

24. Wallston KA, Cawthon C, McNaughton CD, Rothman RL, Osborn CY, Kripalani S. Psychometric properties of the brief health literacy screen in clinical practice. *J Gen Intern Med*. 2014;29:119–126. doi: 10.1007/s11606-013-2568-0

25. McNaughton CD, Cavanaugh KL, Kripalani S, Rothman RL, Wallston KA. Validation of a short, 3-item version of the subjective numeracy scale. *Med Decis Making*. 2015;35:932–936. doi: 10.1177/0272989X15581800

26. Smith MS, Wallston KA, Smith CA. The development and validation of the Perceived Health Competence Scale. *Health Educ Res*. 1995;10:51–64. doi: 10.1093/her/10.1.51

27. U.S. Department of Health and Human Services. National Institutes of Health. National Heart, Lung, and Blood Institute. Your guide to lowering blood pressure. NIH Publication No. 03.5232, May 2003. 2003.

28. https://www.nhlbi.nih.gov/files/docs/public/heart/hbp_low.pdf. Accessed December 16, 2020.

29. McNaughton C, Wallston KA, Rothman RL, Marcovitz DE, Storrow AB. Short, subjective measures of numeracy and general health literacy in an adult emergency department. *Acad Emerg Med*. 2011;18:1148–1155. doi: 10.1111/j.1553-2712.2011.01210.x

30. Rothman R. Addressing health literacy: talking plainly to improve patient care. *J R Coll Physicians Edinb*. 2010;40:194–195. doi: 10.4997/JRCPE.2010.301

31. Flowers L. Teach-back improves informed consent. *OR Manager*. 2006;22:25–26.

32. Whitlock EP, Orleans CT, Pender N, Allan J. Evaluating primary care behavioral counseling interventions: an evidence-based approach. *Am J Prev Med*. 2002;22:267–284. doi: 10.1016/S0749-3797(02)00415-4

33. Bowen ME, Cavanaugh KL, Wolff K, Davis D, Gregory RP, Shintani A, Eden S, Wallston K, Elasy T, Rothman RL. The diabetes nutrition education study randomized controlled trial: a comparative effectiveness study of approaches to nutrition in diabetes self-management education. *Patient Educ Couns*. 2016;99:1368–1376. doi: 10.1016/j.pec.2016.03.017

34. Wolff K, Cavanaugh K, Malone R, Hawk V, Gregory BP, Davis D, Wallston K, Rothman RL. The Diabetes Literacy and Numeracy Education Toolkit (DLNET): materials to facilitate diabetes education and management in patients with low literacy and numeracy skills. *Diabetes Educ*. 2009;35:233–236, 238-41, 244-5..

35. Emmons KM, Rollnick S. Motivational interviewing in health care settings. Opportunities and limitations. *Am J Prev Med*. 2001;20:68–74. doi: 10.1016/S0749-3797(00)00254-3

36. Thompson DR, Chair SY, Chan SW, Astin F, Davidson PM, Ski CF. Motivational interviewing: a useful approach to improving cardiovascular health? *J Clin Nurs*. 2011;20:1236–1244. doi: 10.1111/j.1365-2702.2010.03558.x

37. Lane C, Huws-Thomas M, Hood K, Rollnick S, Edwards K, Robling M. Measuring adaptations of motivational interviewing: the development

and validation of the behavior change counseling index (BECCI). *Patient Educ Couns*. 2005;56:166–173. doi: 10.1016/j.pec.2004.01.003

38. Nelson LA, Spieker AJ, Kripalani S, Rothman RL, Roumie CL, Coco J, Fabbri D, Levy P, Collins SP, McNaughton CD. User preferences for and engagement with text messages to support antihypertensive medication adherence: findings from a pilot study evaluating an emergency department-based behavioral intervention. *Patient Educ Couns*. 2021. In press. doi: 10.1016/j.pec.2021.10.011

39. Collins LM, Murphy SA, Nair VN, Strecher VJ. A strategy for optimizing and evaluating behavioral interventions. *Ann Behav Med*. 2005;30:65–73. doi: 10.1207/s15324796abm3001_8

40. Beckett L, Godwin M. The BpTRU automatic blood pressure monitor compared to 24 hour ambulatory blood pressure monitoring in the assessment of blood pressure in patients with hypertension. *BMC Cardiovasc Disord*. 2005;5:18. doi: 10.1186/1471-2261-5-18

41. Kripalani S, Risser J, Gatti ME, Jacobson TA. Development and evaluation of the Adherence to Refills and Medications Scale (ARMS) among low-literacy patients with chronic disease. *Value Health*. 2009;12:118–123. doi: 10.1111/j.1524-4733.2008.00400.x

42. *R: A Language and Environment for Statistical Computing. [computer program]*. Vienna, Austria: R Foundation for Statistical Computing; 2020. https://www.R-project.org/

43. Rubin DB. *Multiple Imputation for Nonresponse in Surveys*. Hoboken, NJ: John Wiley; 2011.

44. Van Buuren S, Brand JPL, Groothuis-Oudshoorn CGM, Rubin DB. Fully conditional specification in multivariate imputation. *J Stat Comput Simul*. 2006;76:1049–1064. doi: 10.1080/10629360600810434

45. Diggle P, Heagerty P, Liang K, Zegar S. *Analysis of Longitudinal Data*. 8th ed. Oxford: Oxford University Press; 2013.

46. Tang N, Stein J, Hsia RY, Maselli JH, Gonzales R. Trends and characteristics of US emergency department visits, 1997–2007. *JAMA*. 2010;304:664–670. doi: 10.1001/jama.2010.1112

47. Niska RW. Blood pressure measurements at emergency department visits by adults: United States, 2007–2008. *NCHS Data Brief*. 2011;72:1–8.

48. McNaughton CD, Brown NJ, Rothman RL, Liu D, Kabagambe EK, Levy PD, Self WH, Storrow AB, Collins SP, Roumie CL. Systolic blood pressure and biochemical assessment of adherence: a cross-sectional analysis in the emergency department. *Hypertension*. 2017;70:307–314. doi: 10.1161/HYPERTENSIONAHA.117.09659

49. Poon SJ, Roumie CL, O'Shea CJ, Fabbri D, R. Coco J, Collins SP, D. Levy P, McNaughton CD. Association of elevated blood pressure in the emergency department with chronically elevated blood pressure. *J Am Heart Assoc*. 2020;9:e015985. doi: 10.1161/JAHA.119.015985

50. Katz EB, Carrier ER, Umscheid CA, Pines JM. Comparative effectiveness of care coordination interventions in the emergency department: a systematic review. *Ann Emerg Med*. 2012;60(1):12–23.e1. doi: 10.1016/j.annemergmed.2012.02.025

51. Mamon J, Green L, Levine DM, Gibson G, Gurley HT. Using the emergency department as a screening site for high blood pressure. A method for improving hypertension detection and appropriate referral. *Med Care*. 1987;25:770–780. doi: 10.1097/00005650-198708000-00010

52. Umscheid CA, Maguire MG, Pines JM, Everett WW, Baren JM, Townsend RR, Mines D, Szyld D, Gross R. Untreated hypertension and the emergency department: a chance to intervene? *Acad Emerg Med*. 2008;15:529–536. doi: 10.1111/j.1553-2712.2008.00132.x

53. Bobrow K, Farmer AJ, Springer D, Shanyinde M, Yu L-M, Brennan T, Rayner B, Namane M, Steyn K, Tarassenko L, et al. Mobile phone text messages to support treatment adherence in adults with high blood pressure (SMS-Text Adherence Support [StAR]): a single-blind, randomized trial. *Circulation*. 2016;133:592–600. doi: 10.1161/CIRCULATIONAHA.115.017530

54. Davoudi A, Lee NS, Chivers C, Delaney T, Asch EL, Reitz C, Mehta SJ, Chaiyachati KH, Mowery DL. Patient interaction phenotypes with an automated remote hypertension monitoring program and their association with blood pressure control: observational study. *J Med Internet Res*. 2020;22:e22493. doi: 10.2196/22493

55. Paz MA, de-La-Sierra A, Sáez M, Barceló MA, Rodríguez JJ, Castro S, Lagarón C, Garrido JM, Vera P, Coll-de-Tuero G. Treatment efficacy of anti-hypertensive drugs in monotherapy or combination: ATOM systematic review and meta-analysis of randomized clinical trials according to PRISMA statement. *Medicine*. 2016;95:e4071. doi: 10.1097/MD.0000000000004071

56. Holt R, Young J, Heseltine D. Effectiveness of a multi-component intervention to reduce delirium incidence in elderly care wards. *Age Ageing*. 2013;42:721–727. doi: 10.1093/ageing/aft120

57. Katz DA, Graber M, Lounsbury P, Vander Weg MW, Phillips EK, Clair C, Horwitz PA, Cai X, Christensen AJ. Multiple risk factor counseling to promote heart-healthy lifestyles in the chest pain observation unit: pilot randomized controlled trial. *Acad Emerg Med*. 2017;24:968–982. doi: 10.1111/acem.13231

58. Bernstein SL, Bijur P, Cooperman N, Jearld S, Arnsten JH, Moadel A, Gallagher EJ. A randomized trial of a multicomponent cessation strategy for emergency department smokers. *Acad Emerg Med*. 2011;18:575–583. doi: 10.1111/j.1553-2712.2011.01097.x

59. Ersel M, Kitapcioglu G, Solak ZA, Yuruktumen A, Karahalli E, Cevrim O. Are emergency department visits really a teachable moment? Smoking cessation promotion in emergency department. *Eur J Emerg Med*. 2010;17:73–79. doi: 10.1097/MEJ.0b013e32832e67d6

60. Williams A, Lindsell C, Rue L, Blomkalns A. Emergency Department education improves patient knowledge of coronary artery disease risk factors but not the accuracy of their own risk perception. *Prev Med*. 2007;44:520–525. doi: 10.1016/j.ypmed.2007.01.011

61. Demark-Wahnefried W, Aziz NM, Rowland JH, Pinto BM. Riding the crest of the teachable moment: promoting long-term health after the diagnosis of cancer. *J Clin Oncol*. 2005;23:5814–5830. doi: 10.1200/JCO.2005.01.230

62. Buis L, Hirzel L, Dawood RM, Dawood KL, Nichols LP, Artinian NT, Schwiebert L, Yarandi HN, Roberson DN, Plegue MA, et al. Text messaging to improve hypertension medication adherence in African Americans from primary care and emergency department settings: results from two randomized feasibility studies. *JMIR Mhealth Uhealth*. 2017;5:e9. doi: 10.2196/mhealth.6630

63. Meurer WJ, Dome M, Brown D, Delemos D, Oska S, Gorom V, Skolarus L. Feasibility of emergency department-initiated, mobile health blood pressure intervention: an exploratory, randomized clinical trial. *Acad Emerg Med*. 2019;26:517–527. doi: 10.1111/acem.13691

64. Nelson LA, Greevy RA, Spieker A, Wallston KA, Elasy TA, Kripalani S, Gentry C, Bergner EM, LeStourgeon LM, Williamson SE, et al. Effects of a tailored text messaging intervention among diverse adults with type 2 diabetes: evidence from the 15-month REACH randomized controlled trial. *Diabetes Care*. 2021;44:26–34. doi: 10.2337/dc20-0961

65. Group SR, Lewis CE, Fine LJ, Beddhu S, Cheung AK, Cushman WC, Cutler JA, Evans GW, Johnson KC, Kitzman DW, et al. Final report of a trial of intensive versus standard blood-pressure control. *N Engl J Med*. 2021;384:1921–1930. doi: 10.1056/NEJMoa1901281

66. Group SR, Wright JT Jr, Williamson JD, Whelton PK, Snyder JK, Sink KM, Rocco MV, Reboussin DM, Rahman M, Oparil S, et al. A randomized trial of intensive versus standard blood-pressure control. *N Engl J Med*. 2015;373:2103–2116. doi: 10.1056/NEJMoa1511939

SUPPLEMENTAL MATERIAL

Data S1: Randomization Scheme

The randomization scheme was devised using the **blockrand** R package, and securely uploaded to the REDCap randomization module. Randomization was stratified by:

- Study site (VUMC and VHA).
- Number of prescribed BP medications (1 or >1).
- Race (white or non-white).
- Gender (male or female).

By default, variable block sizes were used (with sizes 2, 4, 6, and 8).

Within the VHA strata, certain restrictions were placed on the randomized block size due to anticipated small strata-specific sample sizes:

- For strata with an anticipated size of $n \leq 20$, the maximum block size was 4.
- For strata with an anticipated size $20 < n \leq 60$, the maximum block size was 6.
- For strata with an anticipated size $n > 60$, the maximum block size was 8.

BLOOD PRESSURE CONTROL

Why should I care about blood pressure?

- Many people with diabetes have high blood pressure (sometimes called "high blood").

- Keeping your blood pressure in control can help to prevent a heart attack, stroke, and kidney damage.

- Blood pressure is measured with a cuff. The goal is to get the top blood pressure number below 140 and the bottom number below 90.

Top Number	140
Bottom Number	90

8 - Blood Pressure Control

1

BLOOD PRESSURE CONTROL

To Control Your Blood Pressure

• **Watch your salt!**

- • Don't put salt on foods.
- • Use other things like hot sauce, Mrs. Dash, or herbs to add flavor.
- • Try not to eat fast food, canned soups, vegetable juice, or chips.
- • Eat more fresh foods like fresh vegetables.

Limit use of salt

Limit these foods

• **Watch your weight!**

- • Limit fast food, restaurant foods, and frozen meals.
- • Try to limit fats and starches.
- • Eat smaller portions.
- • Eat more fresh vegetables.

Eat more of these foods

• **Stay active!**

- • Try to walk or do other activities every day!
- • Park far away!
- • Take the stairs instead of the elevator.
- • Do gardening, mow the lawn, or rake leaves.

Following these steps can help lower your blood pressure!

BLOOD PRESSURE CONTROL

Take Your Blood Pressure Pills!

• Remember to take your pills every day.

• Ask your family members to help you with your medicines.

• Use alarms, notes, or pill boxes to help you remember.

• Do not share your medicine with others.

• Tell the doctor or nurse if you have side effects or cannot afford your medicine.

• Tell your doctor or nurse if you run out of medicine.

Blood Pressure Pills

Breakfast Dose

Take_____ pills of _____ at _____

Take_____ pills of _____ at _____

Take_____ pills of _____ at _____

Lunch Dose

Take_____ pills of _____ at _____

Take_____ pills of _____ at _____

Take_____ pills of _____ at _____

Supper Dose

Take_____ pills of _____ at _____

Take_____ pills of _____ at _____

Take_____ pills of _____ at _____

Bedtime Dose

Take_____ pills of _____ at _____

Take_____ pills of _____ at _____

Take_____ pills of _____ at _____

BLOOD PRESSURE CONTROL

I CAN DO IT!

I can help control my blood pressure!

I will pick a goal from the list below to start this week and continue until I talk about it with my doctor, nurse, or dietitian. I will:

☐ _____

_____

_____

☐ Put my pills in a pill box to help me remember when to take them.

☐ Watch my salt by _____.

☐ Limit fast food to _____ meals per week.

☐ Use low-salt spices like lemon juice, black pepper, or hot sauce instead of plain salt, soy sauce, or garlic salt.
   I will use _____
   instead of _____.

☐ Walk 15-30 min _____ days per week.
   I will start walking on this date:_____

_____

4

Data S3: Text Message Content

1. Welcome Message

Hello from your VERB Research Team: We are excited to get started – your help with this study is very important!

2. Reminder Message

Hello from your VERB Team: Have you taken your medicine today?

3. Request for confirmation of message receipt, added January 4, 2017

Reply with 'Y' to let us know you got this message. Thank you!

4. Informational Messages

1. *Hello from your VERB Team: Did you know that more than 1 in 3 adults in the US have high blood pressure? Visit http://goo.gl/RZjllz to learn more.*

2. *Hello from your VERB Team: Did you know that 3 out of 4 Americans say they do not always take their medicines correctly? Usually they say it's because of more than one reason. Visit http://www.scriptyourfuture.org/faqs-2/ to learn more.*

3. *Hello from your VERB Team: Did you know that blood pressure is the force of blood pushing up against your blood vessel walls? Just like too much water pressure can damage a garden hose, high blood pressure can damage your arteries. Visit http://goo.gl/RZjllz to learn more.*

4. *Hello from your VERB Team with tips for taking medicine: Motivation is what gets you started. Habit is what keeps you going. Taking medicines every day can be hard. Creating a routine that fits your life can be key. Visit http://www.scriptyourfuture.org/tools/ to learn more.*

5. *Hello from your VERB Team: Did you know you can't tell how high blood pressure is by how you feel? That's why it is important to use a blood pressure machine to tell if your blood pressure is high. Visit http://goo.gl/lQgcxo to learn more.*

6. *Hello from your VERB Team with tips for taking medicine: Pill boxes are a handy way to keep your medications sorted – plus they show whether you've already taken pills.*

7. *Hello from your VERB Team with tips for taking medicine: A routine, like taking medicine after brushing your teeth, may help you remember to take and refill blood pressure medicine. Visit http://www.scriptyourfuture.org to learn more.*

8. *Hello from your VERB Team with tips for measuring blood pressure: rest 5 minutes, uncross legs, sit with your back supported by a chair; avoid a big meal, caffeine, and tobacco 30 minutes before.*

9. *Hello from your VERB Team with tips for taking medicine: Sometimes it is helpful to have a 'Plan B Routine' for taking your medicines. Family and friends can also help with reminders to take medicine.*

10. *Hello from your VERB Team: Did you know your risk of heart attack or stroke drops 50% when blood pressure is lowered by 20 points for the top number (systolic) or 10 points for the bottom number (diastolic)? Visit http://goo.gl/RZjllz to learn more.*

11. *Hello from your VERB Team: Doing chores at home can be a great way to get activity into your day, raise heart rate, and get things done! Every bit of exercise makes a difference in your health. Visit http://goo.gl/QXp1n2 to learn more.*

12. *Hello from your VERB Team with tips for taking medicine: Some pharmacies can do automatic refills or refill reminders – ask your pharmacist for programs that may work for you.*

13. *Hello from your VERB Team with tips for taking medicine: Medicine can be expensive! If your blood pressure medicine costs too much, let your doctor know so together you can work on a solution. Visit https://www.benefitscheckup.org to learn more.*

14. *Hello from your VERB Team with tips about medicine: If you think you may have side effects from medicine, let your doctor know so together you can work on a solution.*

15. *Hello from your VERB Team: Did you know that sitting all day and being in a hot tub can raise your blood pressure? Visit http://goo.gl/l1TZH9 to learn about what else raises blood pressure.*

5. End Message

Hello from your VERB Research Team: This is the last message – thank you for your important help with this study! We look forward to seeing you at the next study visit.

Table S1. Participant demographics among participants enrolled after text messages requested confirmation of receipt. Continuous values are reported as medians, with first and third quartiles; discrete variables are reported as absolute and relative frequencies.

	Total (n=128)	Education (n=65)	VERB (n=63)
Age, years	51.5 (42, 62)	51 (42, 60)	53 (41.5, 65)
Female, no. (%)	69/128 (53.8)	34/65 (52.3)	35/63 (55.6)
Race, no. (%)			
White	66/128 (51.6)	31/65 (47.7)	35/63 (55.6)
Black	55/128 (42.9)	29/65 (44.6)	26/63 (41.3)
Other	7/128 (5.5)	5/65 (7.7)	2/63 (3.2)
Prescribed BP medications:			
1, no. (%)	58/128 (45.3)	29/65 (44.6)	29/63 (46.0)
>1, no. (%)	70/128 (54.7)	36/65 (55.4)	34/63 (54.0)
Health insurance, no. (%)			
Private	64/125 (51.2)	34/63 (54.0)	30/62 (48.4)
Government Insurance	50/125 (40.0)	20/63 (31.7)	30/62 (48.4)
Uninsured/Self/Unknown	10/125 (8.0)	8/63 (12.7)	2/62 (3.2)
Work-related injury	1/125 (0.8)	1/63 (1.6)	0/62 (0.0)
Total education, years	14 (12, 16)	14 (12, 16)	14 (12, 16)
Household income (x$1,000's),	36 (20, 75)	40 (21, 75)	35 (20, 73.8)
Diabetes, no. (%)	34/127 (26.8)	15/64 (23.4)	19/63 (30.2)
BP monitor at home, no. (%)	77/128 (60.2)	42/65 (64.6)	35/63 (55.6)
Enrollment SBP (mm Hg)	135 (126, 153)	133 (124, 145)	136 (128, 154)
Enrollment DBP (mm Hg)	85 (78, 96)	82 (76, 95)	86 (79, 96)
Enrollment ARMS-7[1]	9 (8, 11)	9 (7, 11)	9 (8, 12)
BHLS[2]	14 (11.5, 15)	14 (12, 15)	15 (11, 15)
SNS[3]	14 (10, 17)	14 (11, 17)	14 (10, 16)
PHQ-2[4]	1 (0, 3)	1 (0, 3)	1 (0, 2)
PHCS-2[5]	8 (7, 10)	8 (7, 10)	8 (7, 9)
GTH[6]	33 (27, 37.5)	31 (26, 39)	33 (28.25, 36)
Enrollment site, no. (%)			
VUMC[7]	111/128 (86.7)	56/65 (86.2)	55/63 (87.3)
VHA[8]	17/128 (13.3)	9/65 (13.8)	8/63 (12.7)

[1] ARMS-7, adherence to refills and medications scale (higher = less adherent)
[2] BHLS, brief health literacy survey (higher = greater health literacy)
[3] SNS, subjective numeracy scale (higher = greater numeracy)
[4] PHQ-2, patient health questionnaire-2 (higher = worse)
[5] PHCS-2, perceived health confidence scale (higher = greater)
[6] GTH, Global Total Health (higher = healthier)
[7] VUMC, Vanderbilt University Medical Center
[8] VHA, Veterans Health Administration

Figure S1. Distribution of text-message response rates (proportion of text messages receiving a response) among participants assigned to the VERB arm after the interactive text message feature became available.
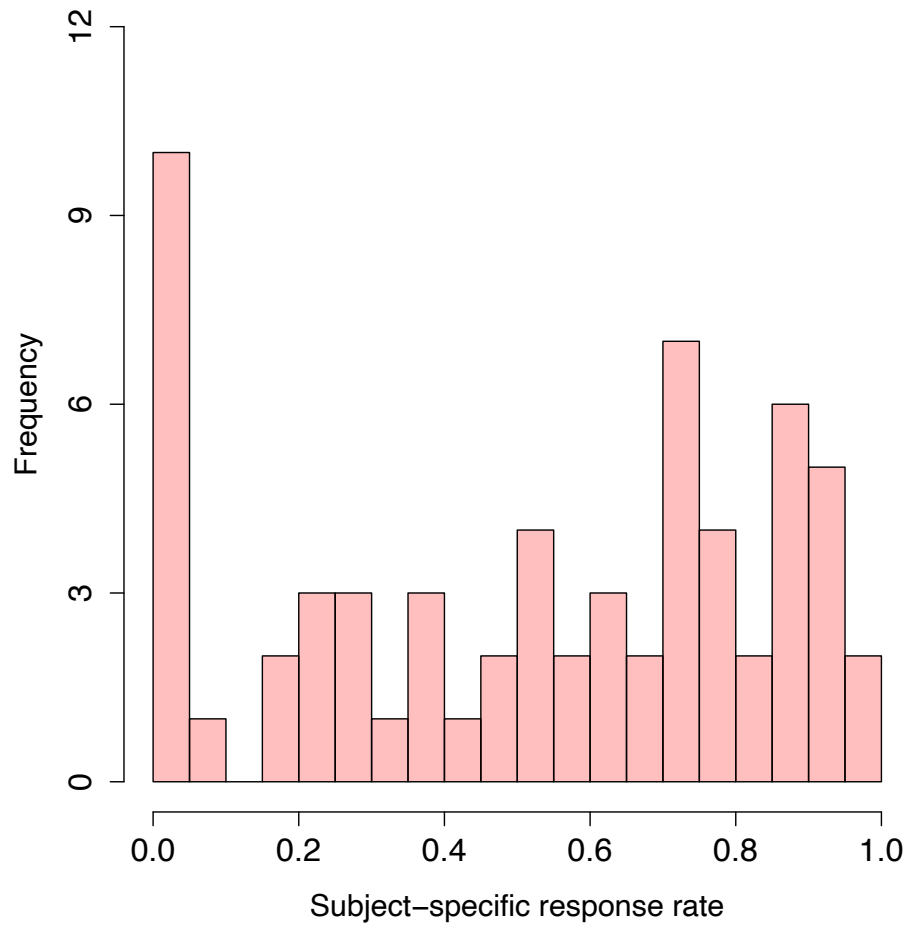
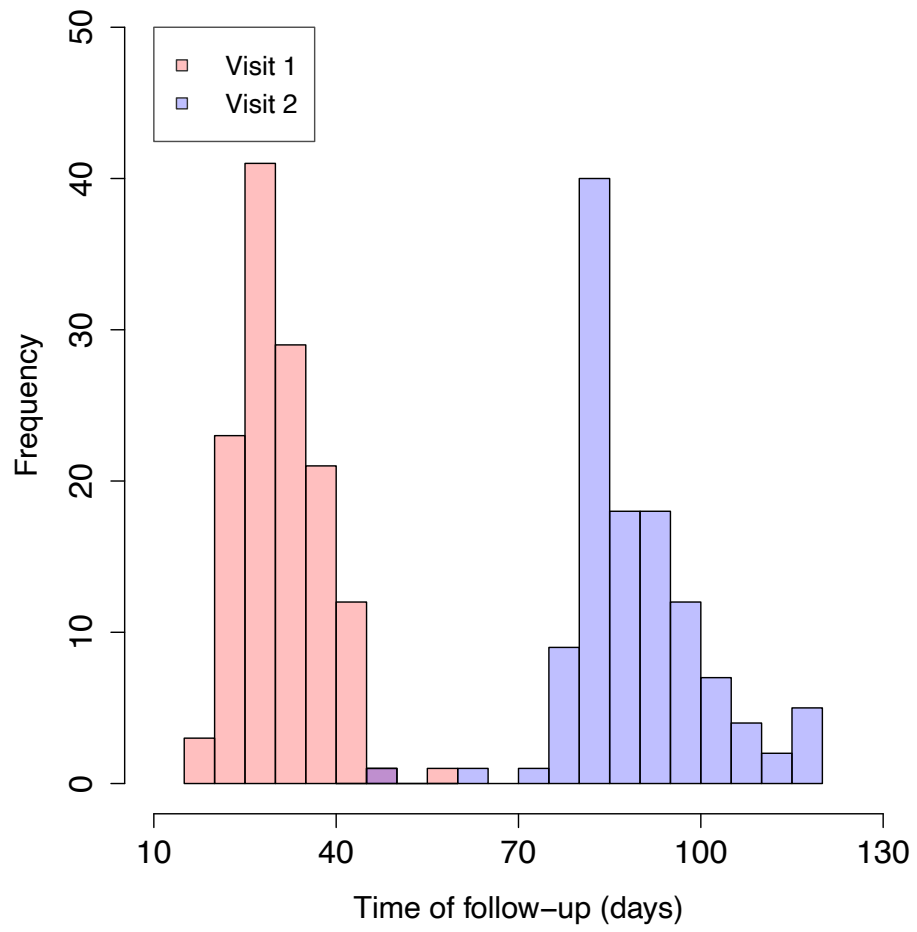**Figure S2**. Distribution of follow-up times for all study participants.

Figure S3. Distribution of time spent on research procedures by study arm.