The accuracy of self-reported blood pressure in the Medication adherence Improvement Support App For Engagement–Blood Pressure (MedISAFE-BP) trial: Implications for pragmatic trials

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Self-report of health conditions and behaviors is one potential strategy to increase the pace of enrollment into pragmatic clinical trials. In this study, we assessed the accuracy of self-reported poorly controlled hypertension among adults in the community who were screened for participation in the MedISAFE-BP trial. Of individuals who self-reported poorly controlled hypertension using the online trial enrollment platform, 64% had a systolic blood pressure less than 140 mm Hg when measured at home. Although we identified several characteristics associated with accurate self-report including older age (odds ratio [OR] 1.02 per year, 95% CI 1.01-1.03), diabetes (OR 1.59, 95% CI 1.17-2.14), and low health activation (OR 1.56 95% CI 1.17-2.07), we were unable to identify patients for whom self-reported hypertension would be a reliable method for their inclusion in a pragmatic trial. (Am Heart J 2020;220:xxx-xxx.)

Randomized controlled trials (RCTs) are widely considered to be the most internally valid source of evidence for health care decision making, but RCTs have several limitations.[1] Traditional RCTs are expensive, may take years to complete, and are frequently conducted in highly controlled environments. In contrast, medical decision making requires rapidly available, high-quality evidence from real-world settings. This discrepancy between traditional RCTs and the needs of clinical providers has resulted in a growing interest in pragmatic trials.[2]

Methods to improve the speed with which pragmatic trials are conducted have received increasing attention.[2] These efforts have included more efficient or targeted recruitment of participants through online platforms,[3] which often rely on potential subjects to self-report their medical conditions or health behaviors. Online self-report has successfully been used to recruit active smokers,[4] patients with depression,[5] and cancer survivors[6] into pragmatic clinical trials. Less is known about whether self-report can be reliably used for more clinically oriented inclusion criteria, such as biometric values, or more nuanced diagnoses like a poorly controlled medical condition. The accuracy of self-report is particularly valuable when studying hypertension, where community-based measurements may be more reflective of daily blood pressure control than office-based measurements.[7]

In this study, we used home blood pressure values collected at enrollment in the Medication adherence Improvement Support App For Engagement–Blood Pressure (MedISAFE-BP) trial to evaluate the accuracy of patients' self-report that they had poorly controlled hypertension. We also sought to identify predictors of concordance between self-reported and measured blood pressure control.

1. Methods

1.1. Study design

Details of the MedISAFE-BP trial have been published previously[8]; and it is registered on clinicaltrials.gov (NCT02727543). Briefly, this was a pragmatic randomized controlled trial of patients with poorly controlled hypertension testing the effects of the Medisafe smartphone application on self-reported medication adherence and

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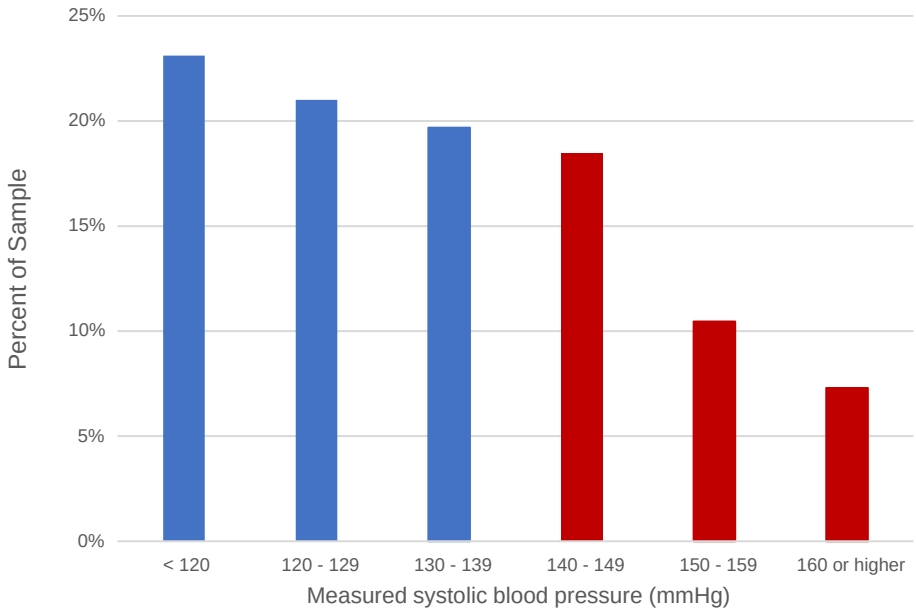
Figure 1



Proportion of patients in each decile of SBP when measured at home.Note: Blue indicates blood pressures that were considered "controlled," and red indicates blood pressures that were considered "uncontrolled."

systolic blood pressure (SBP) control. Potentially eligible subjects were recruited from the community using an online study platform (Achievement Studies; Evidation Health Inc, San Mateo, CA). Participants were screened for poorly controlled hypertension using the question: "Some people have blood pressure that is higher than their doctor would like for it to be, even if they've been prescribed medication. Have you had a blood pressure measurement higher than 140/90 mm Hg in the last month?" Subjects also completed a baseline demographics survey, the Morisky Medication Adherence Scale–8-item (MMAS-8),[9-11] and the Consumer Health Activation Index (CHAI).[12]

Participants who met eligibility criteria and reported poorly controlled blood pressure were mailed a home blood pressure cuff (A&D Medical, UA-651 BLE) and asked to submit 2 home measurements 5 minutes apart, both taken while resting in a seated position with feet on the floor. Participants could earn $10 for completing baseline questionnaires and reporting 2 blood pressure measurements. Individuals with complete baseline data and who reported both measurements were included in this analysis.

1.2. Statistical analysis

Home blood pressure measurements were considered "controlled" if the SBP was less than 140 mm Hg and "uncontrolled" if it was 140 mm Hg or higher consistent with the standard of care during study recruitment (April through September 2016). Characteristics of patients with controlled and uncontrolled blood pressures were compared using t tests and χ^2 tests for continuous and categorical variables, respectively.

We then evaluated potential predictors of uncontrolled blood pressure. We fit univariate and multivariate logistic regression models using self-reported age, sex, race, body mass index (BMI) $\geq$30 kg/m^2, physical activity, education, current smoking, low medication adherence, low activation, and history of myocardial infarction (MI), stroke, diabetes mellitus, or high cholesterol. BMI was calculated from self-reported height and weight and categorized as BMI <30 or BMI $\geq$30. Physical activity was categorized by hours per week: <1, 1-2.5, and >2.5. Race was categorized as white, black, and other. Education was grouped into high school degree or less, college or vocational degree (including some college), and graduate degree. Baseline adherence was classified as low based on the participant's MMAS-8 score,[9-11] and activation as low if the patient's CHAI score was <80, both based on standard cut points for each survey.

We then used generalized boosted regression models to evaluate the predictive ability of the multivariable regression. Boosted regression is a machine learning method that is robust to multicollinearity and overfitting and is commonly used to evaluate prediction models.[13] Using the gbm package in R with 5-fold cross-validation and a learning rate of 0.001, we measured the relative influence of variables in the model and generated a *C*-

Table 1. Characteristics of patients with controlled and uncontrolled blood pressure

	Controlled BP (n = 726)	Uncontrolled BP (n = 412)	*P* value
Age (mean [SD])	49.0 (10.4)	51.4 (10.2)	<.001*
Male (n [%])	262 (36.1%)	163 (39.6%)	.244
BMI ≥30 (n [%])	520 (71.6%)	311 (75.5%)	.158
Current smoking	83 (11.4%)	62 (15.0%)	.079
Education (n [%])			
High school graduate or below	85 (11.7%)	60 (14.6%)	.331
College or vocational degree	526 (72.4%)	284 (68.9%)	
Graduate degree	115 (15.8%)	68 (16.5%)	
Ethnicity (n [%])			
Caucasian/white	490 (67.5%)	266 (64.6%)	.292
Black/African-American	181 (24.9%)	104 (25.2%)	
Other	55 (7.6%)	42 (10.2%)	
Physical activity (n [%])			
<1 h/wk	173 (23.8%)	119 (28.9%)	.082
1–2.5 h/wk	358 (49.3%)	202 (49.0%)	
>2.5 h/wk	195 (26.9%)	91 (22.1%)	
Comorbidities (n [%])			
Prior myocardial infarction	27 (3.7%)	9 (2.2%)	.155
Prior stroke	15 (2.1%)	19 (4.61%)	.015*
Dyslipidemia	283 (39.0%)	176 (42.7%)	.217
Diabetes	118 (16.2%)	97 (23.5%)	.003*
Low adherence (n [%])	362 (49.9%)	215 (52.2%)	.451
Low activation (n [%])	508 (70.0%)	323 (78.4%)	.002*

Low adherence was defined based on MMAS-8 score.[9-11] *Low activation* was defined as CHAI <80. Use of the MMAS is protected by US copyright laws. Permission for use is required. A license agreement is available from Donald E. Morisky, ScD, ScM, MSPH, Professor, Department of Community Health Sciences, UCLA Fielding School of Public Health, 650 Charles E. Young Dr S, Los Angeles, CA 90095-1772, dmorisky@ucla.edu.

* Significance at $P < .05$ level.

statistic. *C*-statistics are used to evaluate a model's discriminative ability with values between 0.5 (indicating prediction no better than chance) and 1.0 (indicating perfect prediction). Analyses were performed using SAS version 9.4 (Cary, NC) and R version 3.5.1.

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2. Results

Of an initial 5,577 patients screened for eligibility for the MedISAFE-BP trial, 2,917 met initial eligibility criteria and were mailed blood pressure cuffs. Of these, 1,160 provided home measurements. The median time between initiating the screening questionnaire to submitting home measurements was 16.4 days (IQR 11.2-26.3). Twenty-two patients were excluded because of incomplete baseline questionnaires (<2%), leaving 1,138 patients with complete information included in our analysis.

The distribution of home blood pressure values is presented in Figure 1. Although all subjects self-reported having poorly controlled blood pressure, 726 (64%) had an SBP less than 140 mm Hg when measured at home.

Characteristics of patients whose blood pressures were measured to be uncontrolled (ie, concordant with self-report) and controlled (ie, discordant with self-report) are presented in Table 1. In unadjusted models, characteristics associated with concordance between self-reported and measured blood pressure were older age (odds ratio [OR] 1.02 per year, 95% CI 1.01-1.03), history of stroke (OR 2.29, 95% CI 1.15-4.56), diabetes (OR 1.59, 95% CI 1.17-2.14), and low health activation (OR 1.56 95% CI 1.17-2.07) (Table 2). Compared to those who exercised less than 1 hour per week, participants who exercised more than 2.5 hours per week were less likely to be concordant (OR 0.68, 95% CI 0.48-0.95). ORs in the fully adjusted model were similar to the unadjusted model for age, diabetes, and low activation but were no longer statistically significant for physical activity and stroke history. In the adjusted model only, patients who reported a race other than black or white were more likely to be concordant (OR 1.61, 95% CI 1.03-2.54) (Table II).

The *C*-statistic using boosted regression with 5-fold cross validation was 0.619. The variables with the highest relative influence in the boosted regression model were age (relative influence 45.3%), diabetes (9.4%), and low activation (9.1%) (Supplementary Figure 1).

3. Discussion

The use of self-reported characteristics to identify eligible patients could potentially substantially increase the pace and reduce the cost of clinical trials. In this study, we used data from the MedISAFE-BP trial to assess concordance between self-reported and home-measured blood pressure. We found that nearly two thirds of patients self-reporting poorly controlled hypertension had an SBP less than 140 mm Hg when measured at home.

There are several possible reasons for the lack of concordance between self-reported and measured blood pressure. First, patients' self-reported blood pressure values may have been based upon those collected in health care settings and thus may reflect “white-coat” hypertension, which is estimated to account for up to 30% of patients with an elevated blood pressure in clinics.[7] Second, normal daily blood pressure variation could result in measurements intermittently above or below the 140 mm Hg cutoff. In the screening question, we asked about just 1 SBP reading greater than 140 mm Hg, which does not necessarily indicate consistently elevated blood pressure. Third, the trial's incentive structure also encouraged answering positively to inclusion criteria. However, our approach likely mirrors how incentives for online recruitment would be done in other trials.

Table 2. Unadjusted and adjusted relationships between baseline covariates and having uncontrolled blood pressure on home measurement*

	Unadjusted OR (95% CI)	Unadjusted p-value	Adjusted OR (95% CI)	Adjusted *P* value
Age	1.02 (1.01–1.03)	<0.001*	1.03 (1.02–1.04)	<.001*
Male	1.16 (0.90–1.49)	0.244	1.29 (0.99–1.68)	.062
BMI ≥30	1.22 (0.92–1.61)	0.159	1.31 (0.97–1.77)	.076
Current smoking	1.37 (0.96–1.95)	0.080	1.40 (0.96–2.03)	.080
Education				
High school grad or below	Ref		Ref	
College or vocational degree	0.76 (0.53–1.10)	0.145	0.78 (0.53–1.15)	.209
Graduate degree	0.84 (0.54–1.31)	0.437	0.86 (0.53–1.38)	.521
Ethnicity				
Caucasian/White	Ref		Ref	
Black/African-American	1.06 (0.80–1.41)	0.695	1.24 (0.91–1.68)	.176
Other	1.407 (0.916–2.16)	0.119	1.61 (1.03–2.54)	.038*
Physical activity				
<1 hour / week	Ref		Ref	
1–2.5 hours / week	0.82 (0.61–1.10)	0.143	0.97 (0.71–1.31)	.828
>2.5 hours / week	0.68 (0.48–0.95)	0.026*	0.80 (0.56–1.14)	.218
Comorbidities				
Prior myocardial infarction	0.58 (0.27–1.24)	0.160	0.46 (0.20–1.04)	.061
Prior stroke	2.29 (1.15–4.56)	0.018*	2.08 (0.99–4.36)	.051
Dyslipidemia	1.17 (0.91–1.49)	0.217	1.03 (0.79–1.34)	.835
Diabetes	1.59 (1.17–2.14)	0.003*	1.50 (1.09–2.06)	.012*
Low adherence	1.10 (0.86–1.40)	0.451	1.08 (0.830–1.401)	.573
Low activation	1.56 (1.17–2.07)	0.002*	1.64 (1.212–2.218)	.001*

OR is per year of age. *Low activation* was defined as CHAI <80. *Low adherence* was defined based on MMAS-8 score.[9-11] Use of the ©MMAS is protected by US copyright laws. Permission for use is required. A license agreement is available from: Donald E. Morisky, ScD, ScM, MSPH, Professor, Department of Community Health Sciences, UCLA Fielding School of Public Health, 650 Charles E. Young Drive South, Los Angeles, CA 90095–1772, dmorisky@ucla.edu.
* Significant at .05 level.

We identified several characteristics of patients who are more likely to accurately self-report having poorly controlled hypertension, including older age, history of diabetes, and low activation. Although prior research shows that many people are unaware of a diagnosis of hypertension,[14] patients in our sample were asked to self-report a more nuanced diagnosis of poor blood pressure control. Our findings are partly consistent with prior research among subgroups that demonstrated greater knowledge of blood pressure among older and higher-income adults.[15] It is possible that older adults and patients with diabetes were more likely to accurately report poorly controlled hypertension because true hypertension, rather than white coat syndrome, is more prevalent in those populations. For activation, it is possible that patients with high scores on the activation scale might be more likely to have been actively managing their chronic conditions and could have taken steps to get their blood pressures under control. Despite these predictive characteristics, we were unable to reliably discriminate between those individuals for whom self-reported poorly controlled hypertension was and was not accurate. This suggests that, unfortunately, self-report alone was not adequate to accurately recruit a cohort with this more nuanced diagnosis into a pragmatic trial.

Our study has some additional limitations. This study recruited online and required that participants use a smartphone. Our results may not be generalizable to other populations less comfortable with technology. In addition, we only studied poorly controlled hypertension, and our findings may not apply to other biometric values or diagnoses.

In conclusion, in this cohort of individuals who self-reported poorly controlled hypertension, almost two thirds had controlled blood pressure when measured at home. Although we identified several characteristics associated with accurate self-report, we were unable to identify patients for whom self-reported hypertension would be a reliable method for their inclusion in a pragmatic trial. Future studies that wish to use self-report of biometric data will need to understand the benefits, tradeoffs, and limitations of this pragmatic design.

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ahj.2019.10.018.

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