Blood Pressure Control in a Hypertension Telemedicine Intervention: Does Distance to Primary Care Matter?

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Although telemedicine may help overcome geographic access barriers, it is unknown whether rural patients receive greater benefits. In a secondary analysis of 503 veterans participating in a hypertension telemedicine study, the authors hypothesized that patients with greater travel distances would have greater improvements in 18-month systolic blood pressure (SBP). Patients were categorized by telemedicine exposure and travel distance to primary care, derived from zip codes. Comparisons were (1) usual care (UC), distance <30 miles (reference); (2) UC, distance ≥30 miles; (3) telemedicine, distance <30 miles; (4) telemedicine, distance ≥30 miles. Compared with patients receiving UC, distance <30 miles (intercept=127.7), no difference in 18-month SBP was observed in patients receiving UC, distance ≥30 miles (0.13 mm Hg, 95% confidence interval [−6.6 to 6.8]); telemedicine, distance <30 miles (−1.1 mm Hg [−7.3 to 5.2]); telemedicine, distance ≥30 miles (−0.80 mm Hg [−6.6 to 5.1]). Although telemedicine may help overcome geographic access barriers, additional studies are needed to identify patients most likely to benefit. *J Clin Hypertens (Greenwich).* 2013;15:723–730.

Primary care providers manage the majority of the 65 million individuals with hypertension in the United States.[1] However, the primary care workforce is currently unable to meet the demand for clinic visits to manage patients with chronic diseases.[2,3] The demand for primary care is expected to increase further with expansion of healthcare availability under the 2010 Patient Protection and Affordable Care Act (PPACA).[4] Furthermore, our current healthcare system is designed to deliver services primarily through face-to-face encounters between a patient and healthcare provider. This model, however, is likely unsustainable as the demand for healthcare services continues to grow.[3,5]

Telemedicine is the use of telecommunication technologies and the exchange of electronic medical information between different sites to improve patients' health status.[6] Telemedicine can support the delivery of health services over geographic distances[7] and increase access to healthcare services for patients who live in rural areas.[8] Telemedicine may also provide an alternative to traditional face-to-face clinic-based encounters by increasing the capacity to manage chronic diseases through non–face-to-face visits.[9] Hypertension telemedicine interventions have been shown to improve blood pressure (BP) control in individuals with hypertension.[10,11] However, in order to optimize the effectiveness of telemedicine interventions in chronic disease management, it is critical to identify characteristics of patients most likely to benefit from this service.

Although telemedicine may increase access to healthcare for patients who live in rural areas, it remains unknown whether those patients with greater travel distances to primary care have improved outcomes with telemedicine interventions compared with those with shorter travel distances. Thus, we sought to determine whether distance to primary care modified the response to a telemedicine intervention designed to improve hypertension control among veterans. We hypothesized that greater travel distance to primary care would be associated with a greater reduction in systolic BP (SBP) among veterans enrolled in a hypertension telemedicine study.

METHODS

Design and Population

We conducted a secondary analysis of patients participating in the randomized controlled Hypertension Intervention Nurse Telemedicine Study (HINTS).[12,13] HINTS evaluated the impact of 3 telephone-based, home BP monitoring interventions vs usual care on BP control at 18 months.[12,13] The interventions in HINTS consisted of (1) telemedicine-based behavioral management intervention focused on evidence-based recommendations for hypertension behaviors and medication adherence and side effects; (2) medication

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management intervention using decision support software; and (3) combined behavior and medication management in which patients received a full dose of both interventions. Patients in the intervention arms received home BP telemonitoring equipment and reported home BP readings to the study team. In this study, the 3 intervention groups in HINTS were combined and compared with the usual care group. Patients in the usual care group received no contacts with the study nurses and did not receive telemonitoring equipment.

Eligible patients were veterans who were assigned to a primary care provider in the general internal medicine clinic at the Veterans Health Administration (VHA) Durham Medical Center (Durham-VAMC) with a diagnosis of hypertension, at least 2 primary care visits in the past 12 months, taking at least 1 antihypertensive medication, mean SBP >140 mm Hg, or mean diastolic BP (DBP) >90 mm Hg in the 12 months preceding enrollment, and an available 18-month SBP. Patient characteristics and clinical data were collected from the electronic medical record and enrollment forms by trained research assistants.

Distance to Primary Care

Distances from the veterans' home residence to the site of primary care (Durham VAMC) were derived from zip codes using Stata geocoding procedures.[14] VHA access parameters target a travel time of less than 30 minutes to primary care for veterans.[15] Given that travel time may vary by mode of transportation, time of day, and season, we dichotomized travel distance to primary care into <30 miles vs ≥30 miles, under the assumption that most patients who traveled less than 30 miles could access care in under 30 minutes.[16] Patients were categorized into 1 of 4 groups: (1) usual care and <30 miles to primary care; (2) usual care and ≥30 miles to primary care; (3) intervention arm and <30 miles to primary care; and (4) intervention arm and ≥30 miles to primary care.

Outcomes: SBP and BP Control at 18 months

The primary outcome was mean 18-month SBP. Each patient had mean SBP and DBP calculated at enrollment and 18 months from 2 in-clinic BPs. All BP measurements were obtained by a trained research assistant who was blinded to group assignment using a standardized research protocol.[13]

The secondary outcome was BP control defined as mean SBP <140 mm Hg and mean DBP <90 mm Hg for patients without diabetes and mean SBP <130 mm Hg and mean DBP <80 mm Hg for patients with diabetes.[17,18]

Covariates and Statistical Analysis

We specified the following covariates a priori for inclusion in regression models: baseline BP (continuous), age (continuous), race (white vs non-white), and marital status (not married vs married). Descriptive statistics including frequency, means, standard deviation, and cross-tabulations were used to describe patient characteristics at baseline. Differences in baseline characteristics across the 4 exposure groups were examined using analysis of variance, Kruskal-Wallis, and chi-square tests.

For the primary analysis, bivariate and multivariate linear regression models examined the relationship between distance to primary care by intervention exposure and 18-month SBP. We report the change in systolic BP from model intercept with corresponding 95% confidence intervals (CIs) among each group.

For the secondary outcome, we examined the relationship between distance to primary care and BP control using multivariate logistic regression models adjusted for the above covariates. The odds ratios (ORs) for 18-month BP control and 95% CIs are reported.

Subgroup and Sensitivity Analysis

In HINTS, intervention patients with uncontrolled enrollment BP had a greater improvement in BP compared with intervention patients with controlled enrollment BP.[12] Therefore, we specified an a priori subgroup analysis to examine the primary endpoints among patients with uncontrolled SBP at enrollment. Given that patients with diabetes may have more frequent primary clinic visits than patients who do not, we also conducted a subgroup analysis restricted to patients with diabetes.

We conducted multiple sensitivity analyses that examined the assumptions utilized in our outcome and exposure definitions. First, to examine the potential impact of missing 18-month BPs, 3 scenarios for missing outcome data were considered in a sensitivity analysis: (1) carry-forward of enrollment BP, (2) assume all 18-month BPs uncontrolled, and (3) assume all 18-month BPs controlled. Second, because we assumed that greater travel distance equates with rural residence, we re-analyzed our data using residence in an urban vs rural area as the primary exposure. Veterans' home residences were classified as urban or rural using a zip code crosswalk developed by the VHA Office of Rural Health.[15] Each veterans' urban/rural status was then paired with exposure to the telemedicine intervention to create 4 exposure groups: (1) urban, usual care; (2) urban, intervention; (3) rural, usual care; and (4) rural, intervention. Additionally, because travel distance is not always concordant with travel time, we also examined travel time to primary care (<30 minutes vs ≥30 minutes) in conjunction with exposure to the telemedicine intervention.

Statistical analyses were conducted using Stata version 10.0 (Stata Corp, College Station, TX).[19] The authors had full access to the data and take responsibility for its integrity. All authors have read and agreed to the manuscript as written. All study participants provided written informed consent, and this study was approved by the Durham VA institutional review board and research and development committee.

RESULTS

Flow of Patients

Of the 591 patients enrolled in HINTS, 503 had an 18-month BP available for inclusion in this analysis. Veterans living <30 miles to primary care (N=167) and ≥30 miles to primary care (N=336) were classified by telemedicine intervention exposure as shown in Figure 1.

Veterans excluded because of missing 18-month SBPs (n=88) were similar to veterans with an 18-month BP except that those without 18-month BP had a higher enrollment BMI (mean and SD [31.7 (6.6) vs 30.2 (5.0); *P*=.02]) and completed fewer primary care clinic visits (median (interquartile range [IQR]) 2 (1–4) vs 5 (3–7); *P*<.001). Loss to follow-up was not differential across the 4 exposure groups (*P*=.65).

Characteristics of Patients

Patient characteristics at baseline are demonstrated in Table I. On average, study patients were 64 years old, 92% male, and 52% non-white. No difference in SBP at enrollment was found across the 4 exposure groups (*P*=.60). At enrollment, 58% of patients had controlled BP with no differences across the 4 groups (*P*=.17). The median (IQR) travel distance was 14 (8–18) miles among intervention and usual care groups living <30 miles and 48 (33–66) miles among intervention and usual care groups living >30 miles from primary care. Patients completed a median of 5 (3–7) primary care visits during the 18-month follow-up period with patients travelling ≥30 miles to primary care having fewer visits than patients travelling <30 miles (4 visits [3–6.5] vs 5 visits [3–9]; *P*=.002).

Primary Outcome: SBP at 18 months

The intercepts from unadjusted and adjusted linear regression analyses are shown in Table II. No difference in 18-month SBP was observed between the 4 exposure groups in unadjusted analysis. In the multivariable linear regression analysis, the model intercept was 128 mm Hg and represents the 18-month SBP for an average male veteran in the usual care group, who is 65 years old, white, married, and lives <30 miles to primary care. Patients exposed to the telemedicine intervention and living <30 miles to primary care had a nonstatistically significant 1.1 mm Hg (95% CI, −7.3 to 5.2; *P*=.74) lower 18-month SBP than the intercept. Patients exposed to the telemedicine intervention and living <30 miles to primary care had a nonstatistically significant 1.1 mm Hg (95% CI, −7.3 to 5.2; *P*=.74) lower 18-month SBP than the intercept. Among veterans receiving the telemedicine intervention and living ≥30 miles to primary care, 18-month SBP was 0.8 mm Hg lower than the intercept (95% CI, −6.6 to 5.1; *P*=.79). A nonsignificant increase in BP (0.13 mm Hg [95% CI, −6.6 to 6.8]) was observed in patients living ≥30 miles from primary care and receiving usual care (Figure 2).

Secondary Outcome: BP Control

There was no difference in BP control at 18 months, with 63% of patients in the usual care and <30 miles to

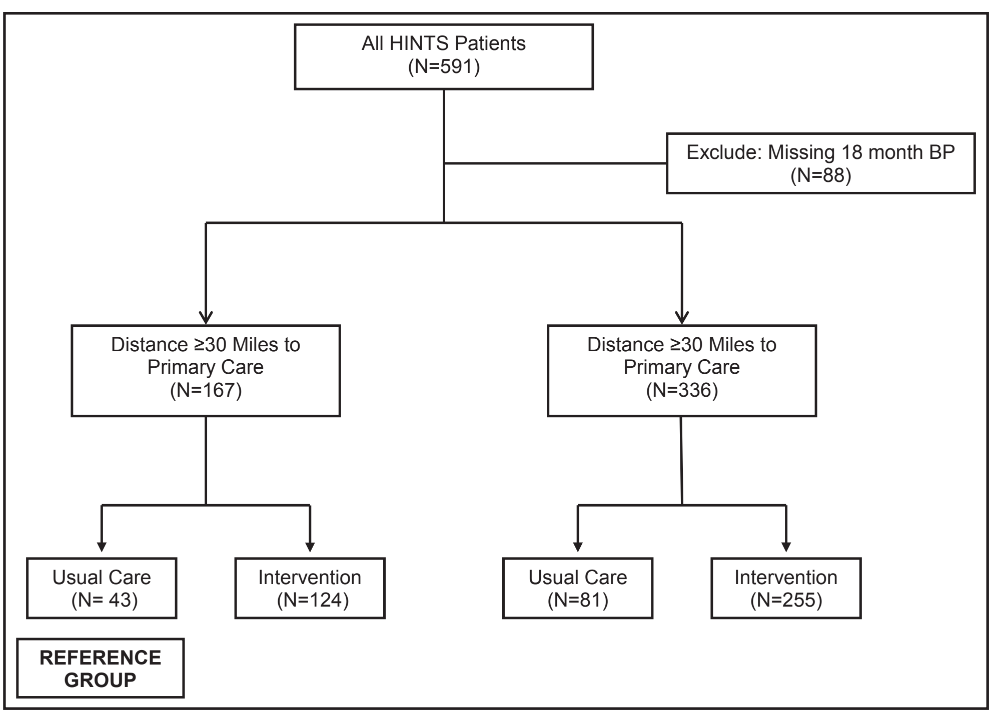

FIGURE 1. Flowchart of patients included in the study. HINTS indicates Hypertension Intervention Nurse Telemedicine Study; BP, blood pressure.

TABLE I. Baseline Patient Characteristics

Patient Characteristic	Distance <30 Miles to Primary Care (N=167) Usual Care (n=43)	Distance <30 Miles to Primary Care (N=167) Intervention (n=124)	Distance ≥30 Miles to Primary Care (N=336) Usual Care (n=81)	Distance ≥30 Miles to Primary Care (N=336) Intervention (n=255)
Age, mean (SD), y	65 (10)	65 (10)	63 (9)	63 (10)
Race, No. (%)				
White	21 (49)	57 (46)	41 (51)	122 (48)
Non-white	22 (51)	67 (54)	40 (49)	133 (52)
Male, No. (%)	42 (98)	116 (94)	76 (94)	229 (90)
Married, No. (%)	27 (63)	88 (71)	54 (67)	168 (66)
Completed <12 years of school, No. (%)	5 (12)	16 (13)	2 (2)	38 (15)
Low literacy (REALM ≤60), No. (%)	16 (37)	37 (30)	38 (47)	99 (39)
Employed, No. (%)	15 (35)	46 (37)	28 (35)	92 (36)
Current smoker, No. (%)	11 (31)	25 (26)	19 (29)	48 (23)
Body mass index, mean (SD), kg/m^2	29 (5)	31 (5)	30 (5)	30 (5)
Diabetes, No. (%)	15 (35)	48 (39)	37 (46)	110 (43)
Distance to primary care, median (IQR), miles	13 (8, 7)	14 (8, 19)	48 (41, 66)	48 (41, 66)
Number of visits, median (IQR)	6 (3, 8)	5 (6, 9)	4 (3, 7)	4 (3, 6)
Baseline systolic BP, mm Hg mean (SD)	130 (21)	131 (21)	127 (14)	129 (20)
Baseline diastolic BP, mm Hg mean (SD)	77 (15)	77 (13)	78 (11)	78 (13)
BP controlled, No. (%)[a]	23 (53)	69 (56)	51 (63)	148 (58)

Abbreviations: SD, standard deviation; IQR, interquartile range; REALM, rapid estimate of adult literacy in medicine. [a]Controlled blood pressure (BP): <130/80 mm Hg in diabetes and <140/90 mm Hg in all other patients.

primary care, 63% of patients in the intervention group and <30 miles to primary care, 61% of patients in the usual care and ≥30 miles to primary care, and 63% of patients in the intervention group and travelling ≥30 miles to primary care having BP controlled (P=.97). No differences in BP control were observed in adjusted analyses (Table II).

Subgroup and Sensitivity Analysis

Subgroup analyses were conducted on the 175 patients with inadequate BP control and the 210 patients with diabetes at baseline. In the adjusted linear regression analysis, the intercept was 129.8 mm Hg (118.6–141.1) among those with an uncontrolled baseline SBP and 126.6 mm Hg (115.7–137.4) among those with diabetes. There was no statistically significant difference from the intercept among the exposure groups (Figure 3).

Two main sensitivity analyses were conducted to determine whether our results were sensitive to the definitions chosen. First, individuals with missing 18-month BP were included in sensitivity analyses. No statistically significant differences in BP control were observed using the carry-forward approach or when missing 18-month BP data were considered all controlled or all uncontrolled (Table III). Second, we examined residence in an urban or rural area as a proxy for travel distance. No difference in the mean SBP at 18 months was observed across the 4 exposure groups (P=.28) or in adjusted analyses (Table III). Similarly, no difference in the primary outcome was observed using travel time to primary care instead of travel distance to primary care in sensitivity analysis.

DISCUSSION

We observed no difference in BP outcomes related to the interaction between travel distance and exposure to a hypertension telemedicine intervention. Patients travelling >30 miles to primary care completed less primary care visits than those travelling <30 miles; however, no difference in the number of completed primary care encounters was observed by exposure to the telemedicine intervention.

Given the ability of telemedicine to mitigate geographic access barriers,[8] it is plausible to expect improved disease outcomes in patients who reside in rural areas. Indeed, patients in rural areas may anecdotally receive greater benefits from telemedicine programs.[20] Although studies have examined health outcomes in rural patients exposed to telemedicine interventions,[21] this is the first study that we are aware of that seeks to determine whether patients travelling farther to their site of primary care may receive greater benefits from telemedicine interventions than those living closer to their site of primary care.

STUDY LIMITATIONS

Although no difference in outcomes was observed, our results may be influenced by a number of factors. First, this study examines a small sample of patients enrolled in a randomized controlled trial and may be underpowered to detect a difference in BP by travel distance. Second, patients in this study were predominantly male, had increased contact with the healthcare system, and may have been more likely to access and navigate the healthcare system as a result of their participation in a randomized controlled trial. Third, our study included a significant proportion of patients with controlled BP at enrollment, which limits the ability to detect a difference and limits the generalizability of our findings to patients with more severe hypertension. Fourth, the 3 telemedicine intervention arms of HINTS were combined in this analysis due to constraints in sample size, resulting in imbalances between the usual care and intervention

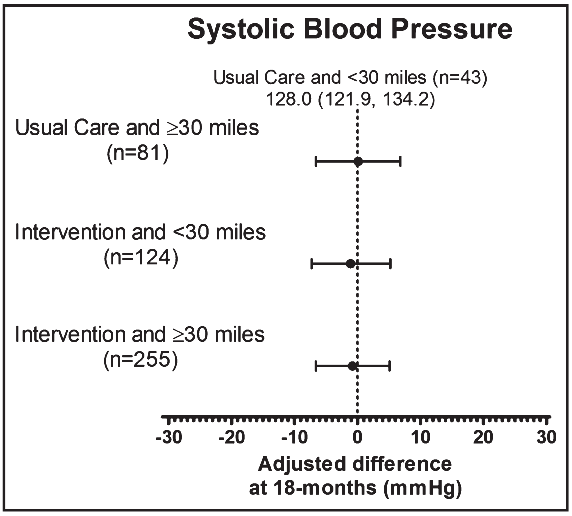

FIGURE 2. Systolic blood pressure at 18 months presented as a change from model intercept, which represents the systolic blood pressure for an average 65-year-old male veteran who is white, married, receiving usual care, and travelling <30 miles to primary care. The model is adjusted for age, race, marital status, and baseline blood pressure.

groups and precluding examination of BP outcomes in each individual study arm. This approach may also mask interactions between travel distance and specific components of the telemedicine intervention. Fifth, variation in travel distance in this sample was limited and precluded examination of outcomes at travel distances >30 miles.

STUDY STRENGTHS

Our study has several strengths. This study was conducted within the VHA, which provides primary care to a large number of rural veterans with a wide range of travel distances to primary care. Additionally, utilization of travel distance rather than urban/rural categorization provides a better estimation of rurality with respect to healthcare access.[15] Our findings did not change when we used an urban/rural classification of the patient's home residence or travel time to primary care rather than travel distance to primary care as our primary exposure.

As hypertension telemedicine programs are designed and implemented, it is critical to understand patient, provider, and health system contextual factors in both positive[10–12,22] and negative[23] studies. However, relatively little is known about the characteristics and demographics of patients who have improved health outcomes in telemedicine interventions. Identification of those most likely to benefit from telemedicine interventions is critical to sustaining and spreading telemedicine programs. This is especially important given that most telemedicine technologies and interventions have failed to demonstrate cost savings compared with conventional health care.[24,25]

Given geographic access barriers,[26] decreased healthcare encounters among rural patients,[27] and urban-rural disparities in treatment of cardiovascular disease,[28] we expected to observe disparities in BP control between urban and rural patients. However, we were surprised to observe no difference in baseline BP by travel distance. Although urban-rural disparities in hypertension control are not well described, findings of previous studies are conflicting. Similar to our findings, others have observed no urban-rural disparities in BP control[29]; however, additional studies have described lower rates of BP control in both urban[30] and rural[28] populations. The lack of urban-rural disparities in BP control in the present study may be related to hypertension management initiatives[31] and initiatives seeking to enhance healthcare access for rural veterans within the VHA.[32] As such, our findings may not apply to patients in non-VHA settings.

TABLE II. Unadjusted and Adjusted BP Outcomes at 18 Months Among the Intervention and Control Groups Travelling <30 Miles or >30 Miles to Primary Care

	Distance <30 Miles to Primary Care (N=167)		Distance ≥30 Miles to Primary Care (N=336)	
	Usual Care (n=43)	Intervention (n=124)	Usual Care (n=81)	Intervention (n=255)
Primary outcome: systolic BP at 18 months				
Systolic BP, mean (SD), mm Hg[a]	127.7 (19)	126.5 (16)	126.6 (19)	126.2 (19.7)
Unadjusted analysis, mm Hg[b]	127.7 (122.1, 133.3)	−1.2 (−7.7, 5.3)	−1.1 (−8.0, 5.8)	−1.5 (−7.6, 4.5)
Adjusted analysis, mm Hg[c]	128.0 (121.9, 134.2)	−1.1 (−7.3, 5.2)	0.13 (−6.5, 6.8)	−0.80 (−6.6, 5.1)
Secondary outcome: odds of BP control at 18 months				
BP controlled, No. (%)[d]	27 (63)	78 (63)	49 (61)	160 (63)
Unadjusted analysis	Reference	1.0 (0.49, 2.1)	0.91 (0.42, 1.9)	1.0 (0.51, 1.9)
Adjusted analysis[e]	Reference	0.96 (0.45, 2.0)	0.78 (0.35, 1.8)	0.94 (0.46, 1.9)

Abbreviation: SD, standard deviation. [a]*P* value by analysis of variance=.97. [b]Unadjusted linear regression analysis in which the intercept represents 18-month systolic blood pressure (BP) among those who were in the usual care group and traveled <30 miles to primary care. Each of the other 3 exposure groups represents a change from the intercept. [c]Adjusted linear regression analysis in which the intercept represents 18-month systolic BP among those who were in the usual care group and traveled <30 miles to primary care while adjusting for baseline BP, age, race, and marital status. [d]BP control: <140/90 mm Hg for those without diabetes and <130/80 mm Hg for those with diabetes; *P* value by chi-square=.99. [e]Logistic regression model adjusted for baseline BP control, age, race, and marital status.

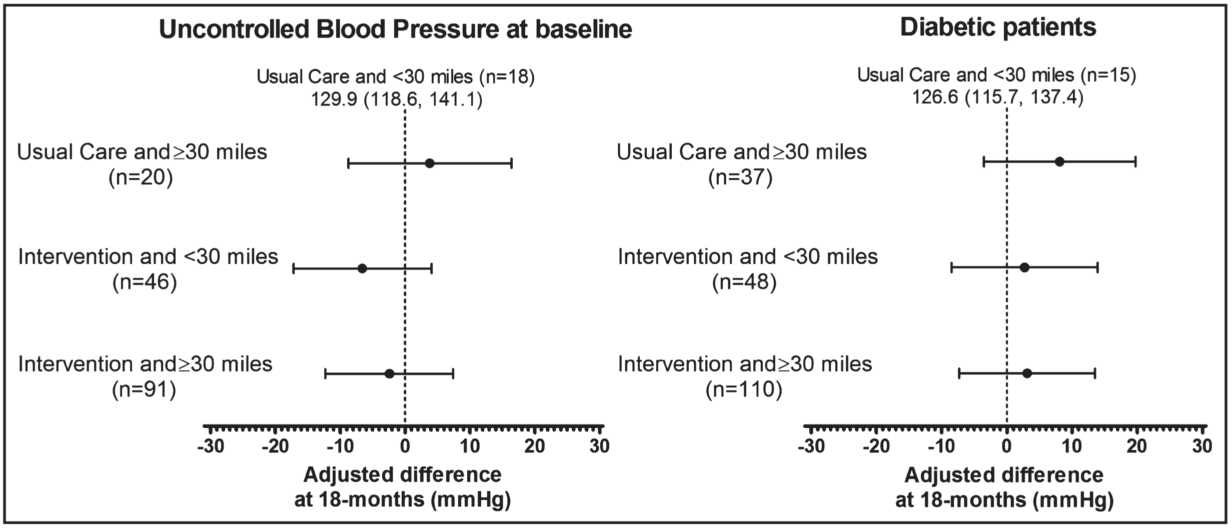

FIGURE 3. Subgroup analysis showing change in systolic blood pressure at 18 months for patients with uncontrolled systolic blood pressure at baseline (N=175) and patients with diabetes (N=210). The model intercept represents the mean systolic blood pressure for an average 65-year-old male veteran who is white, married, receiving usual care, and travelling <30 miles to primary care. Models adjusted for age, race, and marital status, and baseline blood pressure. Controlled blood pressure: <130/80 mm Hg in diabetes and <140/90 mm Hg in all other patients.

TABLE III. Sensitivity Analyses Examining the Impact of Missing 18-Month BP Data and Classification of Travel Distance as Urban or Rural Area of Residence

Odds of BP Control at 18 Months Among Full Cohort Including Patients Missing 18-Month BP[a]				
	Distance <30 Miles to Primary Care (N=194)		Distance ≥30 Miles to Primary Care (N=397)	
	Usual Care (n=48)	Intervention (n=146)	Usual Care (n=99)	Intervention (n=298)
Last measure carried forward BP	Reference	0.96 (0.46, 2.0)	0.80 (0.37, 1.7)	0.95 (0.48, 1.9)
Assume all missing BPs controlled	Reference	1.1 (0.51, 2.2)	0.92 (0.43, 2.0)	1.0 (0.51, 2.0)
Assume all missing BPs uncontrolled	Reference	0.86 (0.43, 1.7)	0.69 (0.34,1.4)	0.86 (0.46, 1.6)
Change in Systolic BP Among Patients With 18-Month BP Using Urban vs Rural Classification[b]				
	Urban (N=279)		Rural (N=224)	
	Usual Care (n=67)	Intervention (n=212)	Usual Care (n=57)	Intervention (n=167)
Mean systolic BP, mm Hg (SD)[c]	128.3 (18)	126.1 (17)	125.5 (19)	126.6 (20)
Unadjusted analysis, mm Hg	128.3 (123.8, 132.7)	−2.2 (−7.3, 3.0)	−2.8 (−9.4, 3.8)	−1.7 (−7.0, 3.6)
Adjusted analysis, mm Hg[d]	129.0 (123.8, 134.3)	−2.0 (−7.0, 2.9)	−1.9 (−8.3, 4.5)	−1.6 (−6.7, 3.5)

Abbreviation: SD, standard deviation. [a]Logistic regression including patients with missing 18-month blood pressure (BP; n=88) under 3 scenarios: (1) last measure carried forward, (2) all controlled, and (3) all uncontrolled. Models adjusted for baseline BP, age, race, and marital status. [b]Urban and rural classification derived from Rural Urban Commuting Area classification. [c]*P* value by analysis of variance=.28. [d]Adjusted linear regression analysis in which the intercept represents 18-month systolic BP among those who were in the usual care and had an urban residence adjusted for baseline BP, age, race, and marital status.

Patients with greater travel distances complete fewer clinical encounters[26] and report being less willing to travel to receive primary care.[33] Our results confirm and expand on this finding by examining completed clinical encounters in the context of a telemedicine intervention. Although veterans with increased travel distances completed fewer primary care encounters, this was not associated with the telemedicine intervention even though many patients prefer the convenience of telemedicine encounters because of the ability of technology to overcome transportation barriers, travel time, and cost.[3,34] This finding may be related to travel pay incentives offered to veterans by the VHA to help overcome financial barriers to travel. Additionally, this practice may also incentivize face-to-face encounters rather than telemedicine encounters for some patients.

The VHA is a leader in the development and implementation of telemedicine technologies.[32] As we move toward team-based models of care such as the Patient-Centered Medical Home model,[35,36] the diffusion of duties and responsibilities from individual providers to the healthcare team creates new opportunities to leverage telemedicine technology and interventions. In this setting, multidisciplinary providers have an opportunity to utilize proven telemedicine interventions to improve disease monitoring, education, and management. In order for telemedicine encounters to help address the access crisis facing primary care, they will need to be utilized in place of, rather than in addition, to regular clinic visits. Although clinic visits every 2 weeks decrease the time to BP and glycemic normalization,[37,38] providers lack capacity to meet this increased clinical demand. In hypertension, home BP monitoring combined with telemedicine interventions achieve similar BP control compared with patients followed up with frequent office visits.[23] Thus, telemedicine may decrease the need for frequent hypertension-related clinic visits and provide an alternative to traditional visit-based encounters for patients. Although our findings suggest that targeting patients with greater travel distances to primary care may not enhance the effectiveness of telemedicine programs, further work is needed to identify patient, provider, and system factors associated with improved outcomes.

CONCLUSIONS

Although telemedicine interventions are frequently targeted at patients who live in rural areas, patients with greater travel distances to primary care did not have greater improvements in BP when enrolled in a hypertension telemedicine intervention. However, given the limitations of the present study, telemedicine may improve outcomes in other settings or at greater travel distances than we were able to evaluate in the present study. As we focus on the delivery of patient-centered care and redesign the delivery of healthcare under the PPACA, telemedicine has the potential to help address shortages in the primary care workforce and expand healthcare access by offering alternative modalities for care delivery. To effectively leverage telemedicine technology and interventions, further study is needed to identify patients most likely to benefit from these services.

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References

1. Egan BM, Zhao Y, Axon RN. US trends in prevalence, awareness, treatment, and control of hypertension, 1988-2008. *JAMA*. 2010;303:2043–2050.
2. Bodenheimer T. Primary care–will it survive? *N Engl J Med*. 2006;355:861–864.
3. Krakoff LR. Management of cardiovascular risk factors is leaving the office: potential impact of telemedicine. *J Clin Hypertens (Greenwich)*. 2011;13:791–794.
4. Carrier ER, Yee T, Stark L. Matching Supply to Demand: Addressing the US Primary Care Workforce Shortage. 2011; http://www.nihcr.org/PCP_Workforce.pdf. Accessed July 3, 2012.
5. Okie S. Innovation in primary care–staying one step ahead of burnout. *N Engl J Med*. 2008;359:2305–2309.
6. American Telemedicine Association. Telemedicine Defined. 2012; http://www.americantelemed.org/i4a/pages/index.cfm?pageid=3333. Accessed July 3, 2012.
7. Field MJ, ed. *Telemedicine: A Guide to Assessing Telecommunications in Health Care*. Washington, DC: National Academies Press; 1996.
8. Hersh WR, Hickam DH, Severance SM, et al. *Telemedicine for the Medicare Population: Update*. Rockville: Agency for Healthcare Research and Quality; 2006.
9. Fortney JC, Burgess JF Jr, Bosworth HB, et al. A re-conceptualization of access for 21st century healthcare. *J Gen Intern Med*. 2011; 26(Suppl 2):639–647.
10. Green BB, Cook AJ, Ralston JD, et al. Effectiveness of home blood pressure monitoring, Web communication, and pharmacist care on hypertension control: a randomized controlled trial. *JAMA*. 2008;299:2857–2867.
11. McManus RJ, Mant J, Bray EP, et al. Telemonitoring and self-management in the control of hypertension (TASMINH2): a randomised controlled trial. *Lancet*. 2010;376:163–172.
12. Bosworth HB, Powers BJ, Olsen MK, et al. Home blood pressure management and improved blood pressure control: results from a randomized controlled trial. *Arch Intern Med*. 2011;171:1173–1180.
13. Bosworth HB, Olsen MK, McCant F, et al. Hypertension Intervention Nurse Telemedicine Study (HINTS): testing a multifactorial tailored behavioral/educational and a medication management intervention for blood pressure control. *Am Heart J*. 2007;153:918–924.
14. Ozimek A, Miles D. Stata utilities for geocoding and generating travel time and travel distance information. *Stata Journal*. 2011;11:106–119.
15. West AN, Lee RE, Shambaugh-Miller MD, et al. Defining "rural" for veterans' health care planning. *J Rural Health*. Fall 2010;26:301–309.
16. Pfeiffer PN, Glass J, Austin K, et al. Impact of distance and facility of initial diagnosis on depression treatment. *Health Serv Res*. 2011;46:768–786.
17. Chobanian AV, Bakris GL, Black HR, et al. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 report. *JAMA*. 2003;289:2560–2572.
18. Diagnosis and Mangement of Hypertension in the Primary Care Setting. 2004; http://www.healthquality.va.gov/Hypertension_Clinical_practice_Guideline.asp. Accessed September 20, 2011.
19. *Stata Statistical Software Release 10* [computer program]. College Station, TX: StataCorp LP; 2007.
20. Peel RK. Rural areas may benefit most. *BMJ*. 2012;345:e5204.
21. Bove AA, Santamore WP, Homko C, et al. Reducing cardiovascular disease risk in medically underserved urban and rural communities. *Am Heart J*. 2011;161:351–359.
22. Bosworth HB, Olsen MK, Grubber JM, et al. Two self-management interventions to improve hypertension control: a randomized trial. *Ann Intern Med*. 2009;151:687–695.
23. Madsen LB, Kirkegaard P, Pedersen EB. Blood pressure control during telemonitoring of home blood pressure. A randomized controlled trial during 6 months. *Blood Press*. 2008;17:78–86.
24. Whitten PS, Mair FS, Haycox A, et al. Systematic review of cost effectiveness studies of telemedicine interventions. *BMJ*. 2002;324:1434–1437.
25. Mistry H. Systematic review of studies of the cost-effectiveness of telemedicine and telecare. Changes in the economic evidence over twenty years. *J Telemed Telecare*. 2012;18:1–6.
26. Chan L, Hart LG, Goodman DC. Geographic access to health care for rural Medicare beneficiaries. *J Rural Health*. Spring 2006;22:140–146.
27. Larson SL, Fleishman JA. Rural-urban differences in usual source of care and ambulatory service use: analyses of national data using Urban Influence Codes. *Med Care*. 2003;41(Suppl 7):III65–III74.
28. Colleran KM, Richards A, Shafer K. Disparities in cardiovascular disease risk and treatment: demographic comparison. *J Investig Med*. 2007;55:415–422.
29. Morden NE, Berke EM, Welsh DE, et al. Quality of care for cardiometabolic disease: associations with mental disorder and rurality. *Med Care*. 2010;48:72–78.
30. King DE, Crisp JR. Rural-urban differences in factors associated with poor blood pressure control among outpatients. *South Med J*. 2006;99:1221–1223.

31. Fletcher RD, Amdur RL, Kolodner R, et al. Blood pressure control among US veterans: a large multiyear analysis of blood pressure data from the Veterans Administration health data repository. *Circulation*. 2012;125:2462–2468.
32. The VHA Office of Rural Health 2012. http://www.ruralhealth.va.gov/index.asp. Accessed June 26, 2012.
33. Buzza C, Ono SS, Turvey C, et al. Distance is relative: unpacking a principal barrier in rural healthcare. *J Gen Intern Med*. 2011;26 (Suppl 2):648–654.
34. Hovey L, Kaylor MB, Alwan M, Resnick HE. Community-based telemonitoring for hypertension management: practical challenges and potential solutions. *Telemed J E Health*. 2011;17:645–651.
35. American Academy of Family Physicians (AAFP), American Academy of Pediatrics (AAP), American College of Physicians (ACP), American Osteopathic Association (AOA). Joint Principles of the Patient-Centered Medical Home. 2007; http://www.acponline.org/running_practice/pcmh/demonstrations/jointprinc_05_17.pdf. Accessed May 15, 2012.
36. American College of Physicians. The Advanced Medical Home: A Patient-Centered, Physician-Guided Model of Health Care. 2006; http://www.acponline.org/advocacy/where_we_stand/policy/adv_med.pdf. Accessed May 15, 2012.
37. Turchin A, Goldberg SI, Shubina M, et al. Encounter frequency and blood pressure in hypertensive patients with diabetes mellitus. *Hypertension*. 2010;56:68–74.
38. Morrison F, Shubina M, Turchin A. Encounter frequency and serum glucose level, blood pressure, and cholesterol level control in patients with diabetes mellitus. *Arch Intern Med*. 2011;171:1542–1550.