Economic evaluation of telephone self-management interventions for blood pressure control

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Background Half of patients with hypertension have poor blood pressure (BP) control. Recent models for treating hypertension have integrated disease monitoring and telephone-based interventions delivered in patients' homes. This study evaluated the costs of the Hypertension Intervention Nurse Telemedicine Study (HINTS), aimed to improve BP control in veterans.

Methods Eligible veterans were randomized to either usual care or 1 of 3 telephone-based intervention groups using home BP telemonitoring: (1) behavioral management, (2) medication management, or (3) combined. Intervention costs were derived from information collected during the trial. Direct medical costs (inpatient, outpatient, and outpatient pharmacy, including hypertension-specific pharmacy) at 18 months by group were calculated using Veterans Affairs (VA) Decision Support System data. Bootstrapped CIs were computed to compare intervention and medical costs between intervention groups and usual care.

Results Patients receiving behavior or medication management showed significant gains in BP control at 12 months; there were no differences in BP control at 18 months. In subgroup analysis, patients with poor baseline BP control receiving combined intervention significantly improved BP at 12 and 18 months. In overall and subgroup samples, average intervention costs were similar in the 3 study arms, and at 18 months, there were no statistically significant differences in direct VA medical costs or total VA costs between treatment arms and usual care.

Conclusions To optimize investment in telephone-based home interventions such as the HINTS, it is important to identify groups of patients who are most likely to benefit from more intensive home BP management. (Am Heart J 2012;163:980-6.)

Controlling hypertension remains one of the biggest challenges faced by the US health care system. Cited as the most common reason for going to the physician among men and women aged ≥45 years,[1] considerable resources are devoted to reduce patients' BP. Despite efforts, half of US patients with hypertension have poor blood pressure (BP) control.[2]

To achieve BP control, new models for treating hypertension have been proposed. Many of these integrate disease monitoring and telephone-based interventions delivered in patients' homes.[3-6] Designed to integrate chronic disease management with home-based care, these interventions aim to improve BP control and avert office visits and related hospitalizations. Although home-based care promises to facilitate disease self-management for patients with chronic conditions, it may be more resource intensive than traditional care in the clinic setting. Few studies have evaluated the tradeoffs between investment in home-based monitoring efforts with downstream health care use and medical costs.[7]

The Hypertension Intervention Nurse Telemedicine Study (HINTS) represented a recent effort to improve BP control by testing a multicomponent intervention of home-based BP monitoring among primary care patients in the Veterans Affairs health care system. In addition to home BP telemonitoring, the HINTS randomized trial compared the effectiveness of 3 telephone interventions with usual care: (1) nurse-administered behavioral management intervention; (2) nurse-administered, physician-directed medication management intervention; or (3) a combined behavioral management and medication management intervention. The trial's primary end points were BP control at 6, 12, and 18 months. The HINTS led to clinically significant improvements in BP control at 12 months; improvements in BP control were not sustained at 18 months.[8]

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Table I. Patient characteristics at baseline by intervention arm

	Total	Usual care	Behavioral management	Medication management	Combined management
n	591	147	148	149	147
Demographics					
Age	64 (10)	64 (10)	63 (11)	64 (10)	63 (10)
Race					
White (%)	49	50	53	49	44
African American (%)	48	48	45	48	52
Other (%)	3	1	3	3	5
Male (%)	92	96	92	93	86
Married (%)	66	65	71	65	61
Education, <12 y (%)	13	10	14	12	18
Low literacy, <ninth grade (%)	38	45	39	32	37
Employed (%)	35	35	34	34	35
Current smoker (%)	21	22	19	20	22
Body mass index	30.3 (5.3)	30.0 (5.5)	30.6 (5.6)	30.2 (5.0)	30.6 (5.1)
Medical history					
>10-y history of high BP (%)	75	71	76	77	74
With diabetes	43	44	44	43	40
Hypertension medications	2.4 (1.2)	2.5 (1.2)	2.4 (1.2)	2.3 (1.1)	2.4 (1.1)
BP					
BP controlled (%)	59	61	58	52	65
Systolic	129 (20)	128 (17)	129 (19)	132 (21)	127 (21)
Diastolic	77 (13)	78 (14)	77 (12)	78 (14)	77 (13)

Notes: Unless otherwise indicated, mean (SDs) are reported. BP control is defined as <140/90 mm Hg for nondiabetic patients and <130/80 mm Hg for diabetic patients.

A secondary goal of the trial and the objective of this study is to evaluate the costs associated with each arm of the intervention and the health care costs incurred by the patients over the 18 months of the study. Cost information about telehealth programs is important because many of them have been implemented[9-13] despite a paucity of research evaluating their costs.[14-17] Understanding the cost of the HINTS interventions, in terms of the intervention and medical care costs, is vital in helping health care systems understand the cost implications of allocating resources among various efforts to improve patients' BP control.

Methods

Intervention: HINTS

The HINTS trial used a 4-group design to evaluate the impact of home BP monitoring and telephone-based interventions on patients with inadequate BP control. Study participants were primary care patients in Durham Veterans Affairs Medical Center (VAMC) general internal medicine clinics, diagnosed with hypertension, used BP lowering medication, and—based on recorded BP in electronic medical records—had inadequate BP control (>140/90 mm Hg) over the prior 12 months. A total of 591 patients were randomized into one of the trial's 4 intervention arms (Table I). The HINTS participants had a mean age of 64 years, half were African American, and 92% were male. Completion rates at 18 months were similar across groups (83%-89%).[8]

Details of the study design and the interventions have been reported elsewhere.[4,8] Briefly, patients who were randomly assigned to an intervention arm received a home BP monitor and telemedicine device to transmit BP measurements. Patients were provided with approximately 10 minutes of training on use of the device and were asked to obtain BP readings every other day (at least 3 readings per week). Intervention was triggered if 2-week average measurements of BP were not in control (≥135/85 for nondiabetic patients and ≥135/80 for diabetic patients).[4,8] Patients who maintained adequate BP control did not activate intervention but triggered nurse contact every 6 months to reinforce their positive behavior.

If home BP control was inadequate in the behavioral intervention, the nurse contacted patients by telephone and administered tailored, patient-specific, and prescripted modules that focused on improving hypertension self-management behaviors. Modules addressed topics such as hypertension knowledge and adverse effects of antihypertensive medication and evidence-based recommendations regarding salt intake, weight, stress reduction, smoking cessation, and alcohol use. In the medication management intervention, a nurse notified a study physician and provided the physician with a medication change recommendation based upon a standardized evidence-based protocol and decision support tool. The study physician consulted with the nurse to review the patient's BP, medication, and adherence and discussed changes in hypertension medication. The nurse communicated recommended changes to the patient by telephone, and the study physician electronically prescribed the medication and generated a note in the patient's medical record. In the combined intervention, the nurse initially addressed recommended medication adjustments followed by tailored behavioral intervention, described above. For patients in usual care, disease management took place in traditional clinic settings, with no home telemonitoring equipment and no contact with intervention nurses.

Table II. Estimated differences in BP control and mean costs between the HINTS interventions and usual care

Outcomes	Behavioral management	Medication management	Combined management
BP control†			
12 m	12.8%* (1.6% to 24.1%)	12.5%* (1.3% to 23.6%)	8.3% (–3.3% to 19.9%)
18 m	–2.9% (–15.0% to 9.3%)	–0.3% (–12.4% to 11.9%)	7.7% (–4.1% to 19.5%)
Per patient costs			
VA medical costs‡			
Inpatient	$781 (–$1968 to $3864)	$1620 (–$1691 to $7449)	$273 (–$2342 to $3093)
Outpatient care	–$289 (–$2035 to $1507)	–$963 (–$2707 to $792)	–$1127 (–$2849 to $676)
Primary care	$49 (–$189 to $303)	–$166 (–$377 to $10)	–$148 (–$351 to $34)
Specialty care	$32 (–$1125 to $1284)	–$570 (–$1624 to $494)	–$622 (–$1704 to $497)
Other care	–$370 (–$1226 to $469)	–$228 (–$1106 to $775)	–$357 (–$1241 to $626)
Outpatient pharmacy	$ 675 ($134 to $1985)*	$193 (–$183 to $628)	$382 (–$85 to $1574)
Hypertension-related pharmacy	$24 (–$48 to $99)	$84 ($12 to $162)*	$21 (–$48 to $100)
Total VA medical costs	$1167 (–$2767 to $5414)	$850 (–$3342 to $7101)	–$472 (–$4213 to $4276)
Total intervention costs	$947	$1275	$1153
Total costs†	$2113 (–$1820 to $6361)	$2125 (–$2068 to $8376)	$681 (–$3061 to $5428)

* $P < .05$.
† Reported figures reflect percentage point change in veterans' BP control. Blood pressure control estimates are marginalized probabilities (with 95% CIs from logistic mixed effects regression models).[18] Positive differences reflect improvement compared with usual care.
‡ Differences in mean costs reported between the HINTS intervention and usual care (with nonparametric bootstrapped bias-corrected 95% CIs). Patients receiving behavioral management incurred, on average, $284 less on outpatient care than patients receiving usual care ($P > .10$).

Table III. The HINTS intervention costs

Category	Description	Unit cost
Start-up costs		
Supplies	Laptop computers (2)	$2000 ($4000 total)
	Computer cases (2)	$189 ($378 total)
Intervention-related costs		
Supplies	Home BP monitor and data transmission device	$550
	Batteries for BP monitor	$9.61
	Pill container	$2.17
Personnel	Nurse time: training/implementation	75 h
	Nurse time: calls with patients	Variable
	Nurse time: call preparation, documentation*	10 min per call (preparation) 15 min per call (documentation)
	Physician time: medical chart review, consultation with nurses	57.30 min per patient
VA medical resource costs (variable)		
Inpatient care†	VAMC admissions	Inpatient care‡
Outpatient care	Primary care office visits Specialty care office visits Other outpatient care‡	
Outpatient pharmacy	Overall prescription fills Hypertension-related prescription fills	

* Patient-variable costs. All other intervention costs are fixed and applied equally across intervention arms and/or patients.
† Total inpatient care costs include associated inpatient laboratory, nursing, pharmacy, radiology, surgery, and all others.[19]
‡ Other outpatient care costs include all other clinic visits (emergency department visits, outpatient laboratory, nursing, radiology, outpatient surgery, and all other outpatient costs).[19]

The primary outcome of the study was BP measured at baseline and 6, 12, and 18 months (Table II). Patients in the behavioral management and medication management arms showed significant improvement in BP control at 12 months; compared with usual care, BP control improved 12.8% and 12.5%, respectively ($P < .05$). Blood pressure control also improved 8.3 percentage points for patients in the combined intervention group, but this change was not statistically significant ($P > .10$). At 18 months, only the combined group showed evidence of improved BP control relative to usual care, although this was not statistically significant (7.7%, $P > .10$).

Cost evaluation

Intervention costs and direct VA medical costs over 18 months comprised total costs. The economic evaluation was performed from the perspective of the VA health care system.

Intervention costs. Intervention costs over the 18 months of the intervention were aggregated across 3 main categories: home BP monitoring, intervention startup, and intervention personnel (Table III).

Home BP monitoring. Variable costs per patient for BP monitoring included costs for the monitor and telemedicine device to transmit BP measures ($550), batteries for the intervention period ($9.61), and medication containers ($2.17).

Intervention startup. Start-up costs were allocated equally across the 3 treatment arms and included 2 laptop computers and cases ($2,000 and $189 each, respectively) for nurses' administration of the interventions. We assumed no overhead costs associated with the intervention because neither additional space nor office equipment was required to integrate these activities into routine care. Likewise, associated costs for the development and maintenance of the intervention's decision support software for this project were considered to be a part of usual clinic care in the VA system and were thus not included in cost calculations.

Intervention personnel. Intervention personnel comprised most intervention costs. The primary cost component of HINTS was compensation for the 2 registered nurses (1.9 full-time equivalent) who administered the 3 intervention arms over

the 18-month trial period. Nurse salary and fringe totaled $90,559 per full-time equivalent based on the federal nurse pay schedule for a grade 2 registered nurse working a 40-hour week at Durham VAMC. We attributed nurses' entire full-time salary and fringe to intervention costs to simulate real-world clinical practice, as nurses administered the intervention program and performed existing clinic duties. In this article, we conservatively estimate nurse costs, although clinic time not devoted to the BP control program would be absorbed in medical center funds if the intervention was implemented in clinical practice. Fixed nurse time costs included 75 hours of intervention training and time spent pilot testing intervention protocols. Variable nurse time intervention costs included the costs of the time nurses spent on the telephone, wherein nurses tracked call frequency and time spent on telephone encounters with patients for delivering the scripted intervention and for troubleshooting. Calls <1 minute in duration (ie, unanswered calls and leaving messages) were excluded. We also assessed nurse preparation and documentation time by call frequency and intervention arm. Nurses spent 10 minutes before each call to patients in the behavioral arm. For patients in the medication and combined intervention arms, nurses prepared 10 minutes before calls and documented medical records 5 minutes after each call. Costs associated with nurse call times were derived from total call time (in hours) and average hourly nurse wage, including fringe.

Variable costs associated with physician time included medical chart review and consultation with nurses for the medication management and combined interventions. Physician time was directly measured over a 35-day period at the height of the study, and the amount of time spent per patient was extrapolated over the entire 18-month intervention period for patients in the medication management and combined intervention arms. The behavioral arm did not require physician time.

Health care use and direct medical costs

Health care use and direct VA medical costs financed and provided by VA at 18 months were drawn from VA administrative files.[20] Data from the VA Decision Support System (DSS) National Data Extract inpatient, outpatient, and pharmacy files were used to generate counts of and costs associated with outpatient and inpatient care as well as outpatient prescription medications filled in the VA system in the 18-month period after participation in the HINTS. Inpatient care included all costs associated with a hospital stay, including inpatient pharmacy costs, laboratories, and tests. For outpatient care, we defined primary care as visits coded to any VA primary care outpatient clinic, including general internal medicine, geriatric clinic, women's clinic, and other screening or preventive care. Outpatient specialty care consisted of visits to outpatient specialty and surgery clinics. Other outpatient care included mental health, ancillary (eg, laboratory or radiology), and emergency department care. To avoid duplication of pharmaceutical costs, outpatient drug costs included in the outpatient cost totals in the DSS outpatient files were removed from outpatient visit cost calculations. Costs of outpatient medications were assessed using the DSS Pharmacy National Data Extract and calculated for all prescription fill costs and hypertension-specific prescription fills (ie, drugs in hypertension drug classes). All outpatient, inpatient, and outpatient pharmacy costs were aggregated to obtain total VA medical costs.

Statistical analysis

To assess differences in clinical outcomes, we used a logistic mixed-effects regression model to estimate differences in BP control at each time point for each of the intervention groups relative to usual care.[8,21] Marginal effects and corresponding CIs for the proportion in BP control for each intervention and usual care group at 12 and 18 months were calculated to estimate the relative change in proportion of BP control. To evaluate the effects of the intervention on health care use and direct medical costs, we used χ^2 tests to compare the proportion of patients hospitalized and Kruskal-Wallis tests to compare median number of patients' outpatient encounters between the intervention groups and usual care group. Because direct medical costs were highly skewed for total VA medical care costs, we used nonparametric bootstrapping methods calculating bias-corrected 95% CIs to compare estimates of total costs between intervention and usual care groups.[22,23]

Sensitivity analysis

We conducted several sensitivity analyses to determine costs under different scenarios of implementation. First, we conducted subgroup analysis to examine differences in costs among patients who were in and out of BP control at baseline. Second, we considered a discount on BP monitoring equipment costs, replacing the $550 telemonitoring equipment (ie, monitor and data transmission devices) with a $50 home BP monitor. Third, we assumed that nurse administration of the intervention was a routine job duty and discounted nurse training costs from intervention costs. Lastly, we combined the BP monitoring and nurse training discounts to calculate intervention costs.

This study was approved by the Institutional Review Board of Durham VA Medical Center (VAMC). The authors are solely responsible for the design and conduct of this study, the drafting and editing of this manuscript, and its final contents.

Results

The HINTS intervention impacts on costs

Intervention costs. Intervention costs per patient (Table IV) were $947 for behavioral management, $1,275 for medication management, and $1,153 for combined behavioral and medication management. Much of the difference in intervention cost was due to differences in physician and nurse time. Over the 18-month intervention, physicians spent an average of 57 minutes per patient administering the medication management and combined intervention. In contrast, nurses constituted most of all intervention costs, handling monthly averages of 120 to 162 patient interactions. Nurses spoke more frequently and spent more time on the telephone with patients in the medication management arm than with patients in the behavioral intervention (288 vs 226 hours total) and combined intervention (288 vs 243 hours total). Substantial time costs were incurred for nurses to prepare before calls and to document conversations in

Table IV. Intervention costs per patient, mean VA medical costs, and total VA costs by intervention arm at 18 months

	Usual care	Behavioral management	Medical management	Combined management
Intervention costs (mean)*	–	$947	$1275	$1153
Total VA Medical Costs,† mean (SD)	$12 328 (16 054)	$13 494 (19 570)	$13 178 (26 738)	$11 856 (20 308)
Inpatient care, mean (SD)	$3379 (11 537)	$4160 (13 832)	$4999 (24 159)	$3652 (12 155)
Outpatient care, mean (SD)	$7423 (7628)	$7134 (7823)	$6460 (7768)	$6297 (7733)
Outpatient pharmacy, mean (SD)	$1525 (1485)	$2200 (4529)	$1718 (2029)	$1907 (4103)
Outpatient pharmacy (HTN), mean (SD)	$310 (280)	$334 (359)	$394 (371)	$331 (362)
Total VA costs,‡ mean (SD)	$12 328 (16 054)	$14 441 (19 570)	$14 453 (26 738)	$13 009 (20 308)

*Intervention costs do not vary by individuals within an intervention arm, so no SD exists.
†Total VA medical cost is an aggregation of inpatient, outpatient (emergency department costs, diagnostic laboratories, nursing, and outpatient surgery), and outpatient pharmacy costs.
‡Total cost is intervention costs plus total medical costs.

the medical record after calls—especially for interventions involving medication management.

Health care use and direct medical costs. The number of primary care and specialty care visits over 18 months was similar for the 4 treatment groups; medians were 4 primary care visits for all groups ($P > .10$) and 5 and 6 for specialty care visits ($P > .10$).

At 18-month follow-up, there were no statistically significant differences in total VA medical care costs between treatment arms and usual care (Table II). Compared with usual care, there was wide variation in inpatient dollars spent by intervention groups, but these differences were not statistically significant. The median cost of inpatient care across all treatment groups was zero, and there were no statistically significant differences in the proportion of hospitalizations among patients across intervention groups. The reported differences in mean inpatient costs are driven by large costs for few outlier patients (not shown). Patients in all 3 intervention arms incurred $289 to $1,127 less on outpatient care compared with those treated under usual care (Table II), but again, these cost savings were not statistically significant. Patients in the medication management arm incurred $84 more on hypertension-related outpatient pharmacy drugs than patients in usual care ($P < .05$), but total outpatient pharmacy costs in the medication management arm were no different from usual care.

Total VA costs. Mean total costs per patient in the treatment arms—including the cost of the intervention and direct medical costs—were not statistically different from usual care ($14,441 behavioral management, $14,453 medication management, $13,009 combined, and $12,328 for usual care).

Sensitivity analyses. Although all patients had met eligibility criteria of inadequate annual BP control in the year before enrollment in the trial, 59% of participants actually had adequate BP at their baseline study visit. For those with poor BP control at baseline, we found significant BP improvement in all 3 intervention arms at 12 months, and for patients receiving the combined intervention, at 18-months compared with usual care.[8] Among the 59% of patients with adequate BP control at the start of the intervention, those in the behavioral intervention incurred more outpatient pharmacy than patients receiving usual care (mean difference of $990, $P < .05$), and patients in the medication management arm incurred fewer outpatient specialty care costs than usual-care patients (mean difference of −$1,391, $P < .05$). For patients out of BP control at baseline (41%), those in the combined management arm incurred an average of $1,303 more on outpatient medications than patients receiving usual care ($P < .05$), and those treated with behavioral management incurred fewer costs for other outpatient care (mean difference of −$1,064, $P < .05$). Otherwise, analysis of in- and out-of-BP control at baseline subgroups did not yield significant differences in total medical or overall costs.

Lastly, sensitivity analyses that discounted BP telemonitoring devices, nursing training costs, or both reduced intervention costs did not change our findings (not shown).

Discussion

Telehealth disease management programs are increasingly implemented in clinical practice but with little empirical evidence about their effectiveness on patient or cost outcomes. In our evaluation of the HINTS trial, patients with home BP telemonitoring and receiving either a nurse-administered behavioral intervention or a nurse/physician medication management intervention showed significant gains in BP control at 12 months. At 18 months, BP control for intervention patients overall was no different than usual care. In subgroup analysis, combined intervention resulted in significant decreases in short-term and longer term BP outcomes among patients with poor baseline BP control,[8] which suggests a benefit of intervention for individuals who may have been more appropriate for intervention.

Our cost analysis results inform a nascent evidence base on chronic disease management modeled in a telephone- and home-based framework. Combined intervention resulted in observed net savings in outpatient care and overall medical care as well as the lowest mean cost difference and total cost, but these differences were not statistically significant relative to the other intervention arms. Nurse contact may have accounted for some difference in intervention costs, but this is unlikely because nurse time costs for the combined intervention were the second least costly of the 3 interventions. The similarities in total VA costs across the HINTS interventions are not surprising, given that VA medical costs were substantially larger than the HINTS intervention costs and that there were no significant differences in health care use. Furthermore, the large variation in medical costs prevented sufficient precision to identify differences with certainty. Altogether, these findings suggest that, unless the HINTS interventions improve BP control and reduce the actual number of clinic events, patient care costs will not change.

Although implementation costs of telephone-based monitoring and disease management were not statistically significantly higher than usual care total costs (ie, intervention and direct medical costs), intervention costs were nontrivial. The HINTS intervention was costly and time-consuming to deliver, especially for interventions involving medication management that required nurse and physician time. From a program cost perspective, implementation on a larger scale likely would entail lower health system costs than seen in this trial. First, nurse costs in this trial were higher than they would be if the HINTS interventions were implemented in a medical center or health system because nurses would be spending time on other clinic tasks rather than the HINTS trial protocols. Second, although intervention start-up and supply costs constituted roughly half of total intervention costs per patient in the HINTS trial, lower cost scenarios that mirror discounts and economies of scale (eg, volume discounts on home BP monitors or reduced training costs for personnel) would lower intervention costs when scaled for wider implementation. These cost reductions would need to be weighed against the health benefits of gains in BP control that are achieved over time.

A limitation of this study merits acknowledgment. We only had access to VA data files when determining postintervention health care use and medical costs, and thus, we were unable to account for health care services provided outside VA (eg, VA-contract care, Medicare). However, VA was likely to be the principle source of health care for the HINTS patients because of the trial's eligibility requirement of active use of VA primary care and study participation that required visits to VA clinics.

Our cost analysis of the HINTS interventions sheds light on several important considerations for wide-scale implementation of telephone-based self-management programs. Although the overall costs of implementing the HINTS interventions were not significantly different from that of usual care, implementation costs are still nontrivial. Health systems are likely to find that intervention costs may be further reduced for wider scale implementation. Second, for telephone-based intervention management programs to be worth their investment, they must create significant improvement in clinical outcomes. The findings from our subgroup analysis suggests that, to optimize investment in home and telephone-based interventions such as the HINTS, it is critically important for health systems to consider applying interventions to specific patient subpopulations that are most likely to benefit from intensive home-based monitoring and self-management efforts. Third, implementation should also consider whether intervention generates other patient-centered outcomes or efficiencies in other aspects of medical care. With overall improvements in 12-month clinical outcomes that were not sustained at 18 months, the long-term return on investment in clinical outcomes remains unclear. It is possible that short-term gains in 12-month BP control produced downstream effects in medical care savings (ie, because of slowing progression of chronic disease) that were not observed in this study. To inform implementation efforts and the refinement of existing programs, future research should quantify the indirect benefits and costs of interventions, assess longer term BP control and health care use and cost outcomes, and examine the extent to which subpopulations may benefit from telephone-based chronic disease management interventions such as those tested in the HINTS.

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