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Incremental Costs associated with Physician and Pharmacist Collaboration to Improve Blood Pressure Control

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Abstract

Study Objective—To compare costs associated with a physician-pharmacist collaborative intervention with costs for usual care.

Design—Cost calculation using healthcare utilization and outcomes from prospective, cluster randomized controlled clinical trials.

Setting—Eleven community-based medical offices in the Midwest.

Patients—496 patients with high blood pressure.

Interventions—A physician-pharmacist collaborative care program to manage hypertension.

Measurements and Main Results—Total costs included provider time, laboratory tests, and antihypertensive medications. Provider time was calculated based on 1) an online survey of intervention pharmacists and 2) National Ambulatory Medical Care Survey. Cost parameters were taken from the Bureau of Labor Statistics, the Medicare laboratory fee schedule, and a publicly available drug price website. The total costs were adjusted for patient characteristics. Adjusted total costs were $774.90 in the intervention group and $445.75 in the control group (difference = $329.16; $p< 0.001$). In a sensitivity analysis, the difference in adjusted total costs between the two groups ranged from $224.27 to $515.56. The intervention cost was $1,338.05 ($329.16/24.6% blood pressure control rate) for each additional patient who attained blood pressure control within six months. The cost over 6 months to lower systolic and diastolic blood pressure 1 mm Hg was $36.25 and $94.32, respectively.

Conclusions—The physician-pharmacist collaborative intervention increased blood pressure control but also increased the cost of care. Additional research, such as a cost-benefit or a cost-minimization analysis, is needed to assess if financial savings related to reduced morbidity and mortality achieved from better blood pressure control outweighs the cost.

Keywords

Hypertension; physician-pharmacist collaboration; costs

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Introduction

One out of three US adults has hypertension, and 50% of these patients have uncontrolled blood pressure (BP)[1], which led to $76.6 billion in costs in 2010.[2] It is critical, therefore, to identify successful strategies for controlling BP and the costs associated with them.

A systematic review found that team-based care was associated with the greatest improvement in BP outcomes.[3] Studies which evaluated costs associated with physician-pharmacist collaboration failed to include the time associated with pharmacist-physician interactions and activities associated with changes in patient medication regimens.[4,5]

Carter et al. found that a physician-pharmacist collaborative intervention significantly lowered BP and increased BP control in two studies.[6,7] Both trials collected prospective data on physician-pharmacist interactions, provider interactions with patients, laboratory tests and medications. The objective of the present study is to comprehensively assess the costs of those interventions for managing hypertension in community-based medical offices.

Methods

This study combined data from two prospective, cluster randomized controlled clinical trials to assess the cost of a physician-pharmacist collaborative intervention for hypertension compared to usual care. The methods and results published elsewhere could assist understanding of the findings presented here.[6,7]

One study implemented a 6-month collaborative intervention, while another study implemented a similar 9-month intervention and measured BP at 6 months. For consistency, we evaluated 6 months of data from each study. The number of subjects reported here differs slightly from those in two earlier reports because we included only patients who had complete 6-month BP data. However, we performed sensitivity analyses including both patients with and without 6-month BP data using conservative assumptions to evaluate whether the results were robust. Further explanation of assumptions can be found in the statistical analysis section. All costs were eventually adjusted to the U.S. dollar value in 2011. This study was approved by the University of Iowa Institutional Review Board.

Intervention

Eleven community-based medical offices in the Midwest were randomized to either a control (n = 6) or intervention (n = 5) group. Lists of existing patients having established relationships with physicians at the clinics with diagnostic codes for hypertension were obtained. Patients who met the study criteria were approached to participate in the studies. Briefly, the inclusion criteria comprised men and women aged 21 and older with high BP but less than 180/110 mm Hg. Both studies had similar inclusion and exclusion criteria. Providers included primary care faculty physicians, specialists who dealt with hypertension (nephrologists and cardiologists), pharmacists and, in some clinics, medical residents. All clinical pharmacists in the intervention group had a Doctor of Pharmacy degree. Providers received no compensation for implementing the interventions or performing collaboration activities.

Provider activities in the intervention group included direct-patient care and provider collaboration. Direct-patient care activities included assessment, recommendations to patients made during clinic visits, and phone follow-ups. Trial protocols encouraged pharmacists to attend clinic visits and to contact patients at baseline and at specific follow-up points to guarantee a minimum amount of care. Furthermore, both trials allowed optional pharmacist contacts at the pharmacists' discretion at points different from the specified ones.

Visits with primary care physicians were not mandated except a baseline visit for the 9-month intervention.[6] Patients saw specialists only when the primary care physician felt this was important.

Physician-pharmacist collaboration was classified using the following activity types: written communication, phone communication, curbside consultation, and face-to-face communication. When appropriate, pharmacists also arranged for a physician visit on a separate scheduled appointment. Pharmacists worked at the same medical offices with physicians and communicated most recommendations via in-person contacts during the time period surrounding the patient visit. Curbside consultation was defined as quick, informal, in-person contact within the clinic for communicating straightforward recommendations. Face-to-face communication was defined as a scheduled consultation or meeting in which a pharmacist had a specific concern or a treatment plan and needed to discuss the case in more detail with a physician. Some physicians gave the pharmacists the authority to make treatment changes per clinic protocol and inform physicians later.

Pharmacists focused on addressing suboptimal medication regimens by recommending therapies consistent with JNC 7 guidelines (The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High BP guidelines)[8], and educating physicians when needed. All therapy changes were approved by the physicians. Pharmacists in these studies did not collaborate with specialists.

Physicians in the control group clinics managed hypertension without pharmacist collaboration. The clinical pharmacists employed at control sites abstained from providing direct care for patients in the control group. However, control group pharmacists were permitted to answer general treatment questions from physicians.

Outcomes

Study outcomes included costs of provider time, laboratory tests, and antihypertensive medications during the six-month period.

Data Sources

Both trials collected data on health care utilization and outcomes. Estimates for base physician visit times, which involved face-to-face contacts with patients, were taken from the 2003 National Ambulatory Medical Care Survey (NAMCS)[9] and counseling was excluded. The physician visit times were applied to primary care physicians and specialists. Times for the remaining activities were estimated using the results of an online survey for pharmacists. The survey was approved by the University of Iowa Institutional Review Board. After both trials had ended, all of the pharmacists who implemented the intervention were invited to voluntarily participate in the survey. Survey questions asked the pharmacists to report the average, shortest, and longest amount of time (minutes) they had spent on specific direct-patient-care and collaboration activities. The shortest and longest amounts of time were used in the sensitivity analyses. Six out of seven (85.7%) intervention pharmacists completed the survey. We calculated mean times and subsequently applied those mean specific activity times to all providers, including primary care physicians, pharmacists, and specialists.

Provider compensation rates included average wage rates plus overhead cost. The following average wage rates were taken from the Occupational Employment Statistics (OES) Survey, Bureau of Labor Statistics (May 2008): family and general practitioners $77.64/hour; other physicians and surgeons $79.33/hour; and pharmacists $50.14/hour. Wages for the OES survey included base rate, cost-of-living allowances, guaranteed pay, hazardous-duty pay, incentive pay including commissions and production bonuses, tips, and on-call pay.[10] Costs

to develop the program were included by adding an overhead rate of $50 per hour for direct care activities and $25 per hour for collaboration activities. We chose $50 per hour to remain conservative based on the usual facility fees[11] and $25 based on the fact that physicians and pharmacists shared overhead costs equally.

Laboratory test costs were estimated from the average of all state Medicare laboratory fees in 2008. Drug prices were obtained from the website www.drugstore.com, a publicly available website which represents market prices for medications. Using the prices from one website enabled application of consistent medication prices for all subjects. Generic prices were utilized when available. Medication names and doses were used to determine a daily cost based on a 30-day supply.

Calculation

Patient-specific costs were calculated for 17 provider activities, 16 laboratory tests, and duration of time on 295 dose-specified antihypertensive agents with different product strengths considered to be unique cost items. We multiplied the number of provider activities used for each patient by the average provider time per service and the provider compensation rate. Patient-specific laboratory costs were estimated by multiplying laboratory tests for each patient by Medicare laboratory costs. When tests were bundled we applied bundled test prices when available. For example, if a patient had two or more different lipid laboratory tests on a given visit (e.g. cholesterol, HDL, LDL, and triglyceride), a bundled lipid panel price was used instead of separate prices for the individual lipid laboratory tests.

This cost analysis assumed that patients purchased all prescribed antihypertensive agents because we did not attempt to estimate any costs related to missed doses. However, self-report medication adherence was assessed in the original studies, and more than 85% of patients were adherent.[6,7] We accounted for drug changes during the intervention. For example, if a patient used drug A for 10 days after enrollment and then drug A was stopped but later was prescribed for 30 days, we assumed that the patient used drug A for 40 days.

Statistical Analysis

All analyses used a significance level of 0.05. We used t-tests and chi-square tests to compare baseline characteristics, provider time, number of healthcare utilization and each cost category between the control group and the intervention group. Because clinic-cluster randomization did not yield fully-balanced patient characteristics between the control and intervention group, costs were adjusted using multiple regression analysis with robust standard errors. The multiple regression models specified patient age, gender, race, marital status, smoking status, alcohol intake, baseline number of medications, baseline number of comorbidities, baseline systolic blood pressure (SBP), and baseline diastolic blood pressure (DBP).

Two sensitivity analyses were performed. Key assumptions assessed in our analysis included (1) the times per provider activity, and (2) the costs assumed for the patients that dropped out of the study. The first sensitivity analysis applied the minimum and maximum activity times from our survey. The second analysis included both patients with complete data and patients who dropped. Because patients who dropped out did not have utilization data, their total costs could not be fully estimated. Instead of applying the mean or median of the total costs in their respective groups, in keeping with the conservative nature of our estimates, we assigned the 25th percentile total costs estimated from the control group to patients dropping out in the control group and the 75th percentile total costs estimated from the intervention group to patients dropping out in the intervention group. All data

management and analyses were accomplished by SAS 9.2 while only adjusted costs with robust standard errors were done by Stata 12.

Results

The study included 496 patients with complete data, 244 in the control group and 252 in the intervention group. Table 1 shows that some patient characteristics were imbalanced between the control group and the intervention group including percentage of African Americans, marital status, number of baseline antihypertensive medications, number of baseline co-morbidities, and baseline BP.

Table 2 shows the average time for each of the 17 provider activities spent by primary care physicians and pharmacists per patient in each study arm. Physicians spent similar amounts of time on direct-patient care in both the control and intervention groups. However, physicians in the intervention group spent less time discussing increasing doses of medications than the physicians in the control group. Over six months, the total time spent by primary care physicians in the intervention group was higher than in the control group (70.65 (SD = 45.79) vs. 48.48 (SD = 47.70) minutes, $p< 0.001$), due to the added average of 22.17 minutes spent on collaboration with pharmacists. Intervention pharmacists spent 114.45 (SD = 43.44) minutes per patient over six months. About 26 minutes, slightly less than 1/4 of the total pharmacist time, was spent collaborating with physicians. Pharmacists in the intervention arm spent the most time on written communication with physicians (15.39 (SD = 15.68) minutes) and discussions with patients when recommending new medications (14.33 (SD = 11.80) minutes).

More laboratory tests were performed in the control group than in the intervention group (Table 3). Creatinine and potassium were the most frequently ordered tests in the control group and in the intervention group, respectively. C-reactive protein and urine microalbumin were the least frequently ordered tests in the control group and in the intervention group, respectively. The intervention group had a higher number of dose-specified antihypertensive agents and a higher number of drug changes (Table 4); however, the adjusted average drug costs per medication in the intervention ($95.99) were not significantly different from those in the control group ($104.92), $p= 0.32$.

Table 5 provides a comparison of unadjusted and adjusted cost estimates for each cost category. The unadjusted difference in total costs between the two groups was smaller than the adjusted difference ($252.71 vs. $329.16). The adjusted costs related to physician and pharmacist time were higher in the intervention group than in the control group ($344.29 vs. $107.07, difference = $237.22, $p< 0.001$). The adjusted costs associated with referral to specialists were low and did not differ between the groups. No significant difference ($p= 0.07$) was found in adjusted laboratory costs between the intervention group ($34.93) and the control group ($42.28). The intervention group had higher total antihypertensive medication costs than the control group ($383.53 vs. $287.64, $p< 0.001$). Antihypertensive medications accounted for 49.5% of costs for the intervention group and 64.5% for the control group. The adjusted total cost of care was higher in the intervention group than in the control group ($774.90 vs. $445.75, difference = $329.16, $p< 0.001$).

In the first sensitivity analysis, the adjusted total cost differences between the intervention and control groups were $224.27 and $515.56 for the minimum and maximum provider time estimates, respectively.

For the second sensitivity analysis, we report only the unadjusted total cost differences as the control variables for subjects who dropped were unavailable. The unadjusted total cost difference between the two groups was $313.60 (intervention = $763.07, N= 299 vs. control

= $449.47, N=288) higher than the unadjusted total cost difference from the analysis using only the patients with complete 6-month data ($252.71).

To put the costs of the intervention into perspective, we performed a multiple regression analysis with the same control variables to find adjusted BP control rates and adjusted BP reduction. Then, we estimated cost-effectiveness ratios. From the multiple regression analysis, 24.6% more patients achieved BP control in the intervention group compared to control group patients (66.0% vs. 41.4%, p <0.001). In addition, the difference in drop of SBP/DBP at 6 months between the intervention and control group was -9.08/-3.49 mm Hg (-21.49/-8.61 mm Hg vs. -12.41/-5.12 mm Hg, p < 0.001).

Three cost-effectiveness ratios were calculated. To determine the cost required to have one additional patient achieve BP control, the change in costs was divided by the change in hypertension control rates, or $329.16/ 24.6% = $1,338.05 per additional patient who achieved controlled BP over six months. To determine the cost required to achieve one additional mm Hg reduction, the total difference in cost was divided by the difference in BP at 6 months, or $329.16/ 9.08 mm Hg = $36.25 per an additional 1.0 mm Hg reduction in SBP and $94.32 per an additional 1.0 mm Hg reduction in DBP.

Discussion

The physician-pharmacist collaborative intervention increased both time and costs of physicians and pharmacists to manage hypertension compared to the control group. However, similar physician visit times occurred in both groups, suggesting that the intervention did not replace physician visits. The time spent on collaboration increased total physician time by 35%, resulting in significantly higher adjusted physician costs in the intervention group ($151.93 vs. $104.33, p< 0.001). As shown in Table 2, physicians in the intervention group spent significantly less time on discussions about increasing doses of medications. Physicians may have delegated or relied on pharmacists to work on those tasks implying delegation of particular functions to the pharmacist.

One might question the relatively low level of mean blood pressure values achieved in the intervention groups in these studies. However, approximately 25% of subjects in these trials had diabetes or chronic kidney disease so their blood pressure goal based on guidelines was <130/80 mm Hg.[8] Therefore, these mean values are representative of what would occur when guidelines are met in similar populations.

A randomized, comparative study by Borenstein et al. found that a physician-pharmacist co-management group had fewer primary care physician visits and incurred lower provider visit costs compared with usual care.[5] The authors suggested that these differences could reflect more effective follow-up in the co-management group. The present study found no significant difference in the number of primary care physician visits. Their study showed significantly lower provider visit costs per patient in the physician-pharmacist co-management group ($160 vs. $195) but the present study found higher total provider costs (primary care physicians and pharmacists) in the physician-pharmacist collaboration group ($344.29 vs. $107.07). One explanation for these differences is that the previous study did not clearly capture collaboration time, instead assigning $20 for a 30-minute pharmacist appointment and $35 for a 15-minute physician appointment.

We found that the physician-pharmacist collaborative intervention resulted in higher BP control, a statistically significant drop in SBP and DBP, and higher total costs compared to care delivered for patients in the control group. Okamoto and Nakahiro[4] found no difference (p= 0.71) in clinic visit costs between pharmacist-managed hypertension ($242.46) and physician-managed hypertension ($233.20). The present study found the cost of this

intervention to be $36.25 for each additional 1.0 mm Hg reduction in SBP, far greater than the $1.18 cost for each 1.0 mm Hg reduction in SBP found by Okamoto and Nakahiro. However, the earlier study did not assign costs to any interactions between physicians and pharmacists. Also, they used acquisition costs for medications, which might not reflect actual drug prices due to discounts, and they did not capture changes in drug regimens. Our study used market medication prices and included costs associated with changing the drug regimen, providing patient education, and collaborating between physicians and pharmacists.

Munroe et al. found that a community-pharmacy intervention substantially reduced monthly healthcare costs in patients with hypertension, hypercholesterolemia, diabetes, and asthma.[12] The pharmacists educated patients and interacted with physicians to initiate early intervention for drug-related problems. The estimated cost-saving ranged from $143.95/patient/month to $293.39/patient/month (when accounting for the possible influence of age, comorbid conditions, and disease severity). This finding suggests that team-based care by physicians and pharmacists might be a promising approach. Recently, a commercial disease-management model, using remote nurse-based call centers for patients with heart failure and diabetes to improve their understanding of diseases, ability to self care, and communication with providers, showed minimal cost savings of $50 to $60 to the various health plans.[13]

The remaining question is whether the present physician-pharmacist collaborative intervention is *ultimately* cost-saving. To evaluate the issue, future research should include our estimates in a cost-benefit analysis that includes the long-term benefits of having BP control and the risks of uncontrolled BP. For example, the lifetime risk of a stroke for an individual with controlled BP is 14.5%, whereas the risk increases to 23.5% with uncontrolled BP.[14] The lifetime risk for heart failure in an individual with controlled BP is 15.8%, whereas this risk increases to 23.5% in individuals with uncontrolled BP.[15] The results from this study alone are insufficient to perform such analyses. Cost-benefit analyses would need to model BP control rates after discontinuation of the intervention. As a start in the process, retrospective evaluations of both studies used in these analyses were performed to determine if the effects were sustainable.[16,17] In both studies, the beneficial difference between the intervention and control groups was maintained for at least 18 months after discontinuation of the intervention. These findings suggest that extrapolating long-term cost and effectiveness is likely to be valid but additional prospective studies need to be conducted to evaluate these relationships.

We acknowledge several limitations in this study. First, our study involved 11 clinics in the Midwest that serve only a small number of minority subjects, even though many provide care for underserved populations. Therefore, the findings cannot be generalized to other settings or other populations. However, the effect size of the drop in BP was significant, and two meta-analyses have found similar trends.[3,18] Second, the collaborative intervention was implemented in settings where physicians and pharmacists already worked together in the same medical offices. Costs to initiate a collaborative program might be different in other settings. However, we addressed this issue by including a large assumed hourly overhead cost component in the analysis. Moreover, the time estimates collected after the original trials can pose recall bias. Future studies should attempt to capture actual time spent by all types of providers on each activity for each patient. Finally, randomized clinical trials may not reflect typical healthcare practice. Nevertheless, providers had substantial discretion in implementing the intervention designed to reflect routine practice. Future research should include minority populations and use diverse settings to assess feasibility of the collaboration. It will be also helpful to evaluate long-term benefits and risks.

Conclusions

The physician-pharmacist collaborative intervention increased healthcare costs, decreased BP levels and increased BP control. However, the social value of any intervention and decisions regarding its worthiness for implementing must be determined by the individual health system and policy makers. Additional research, such as a cost-benefit or a cost-minimization analysis, is needed to determine whether and to what degree the physician-pharmacist collaborative intervention contributes to financial savings.

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Table 1

Descriptive statistics of variables at baseline

	Control group	Intervention group	P-Value
	N = 244	N = 252	
Sex			0.32
Female	57.4%	61.9%	
Male	42.6%	38.1%	
Race/ethnicity			
White/Hispanic	85.7%	89.7%	0.22
African American	10.7%	3.6%	0.003
Others	3.7%	6.8%	0.16
Average age in years (SD)	61.3 (12.9)	59.1 (13.7)	0.06
Married/living as married	54.9%	64.7%	0.03
Smoking status			
Never smoked	44.7%	52.0%	0.11
Current smokers	22.5%	16.3%	0.09
Ex-smokers	32.8%	31.8%	0.85
Alcohol intake			>0.99
None or less than 1 drink per day	86.2%	86.1%	
One or more drink(s) per day	13.8%	13.9%	
Average number of anti-hypertensive agents (SD) at baseline	1.7 (1.0)	1.3 (1.0)	<0.001
Average number of co-existing chronic conditions	0.6 (0.9)	0.4 (0.7)	<0.001
Average baseline systolic blood pressure in mm Hg (SD)	150.8 (12.7)	153.5 (11.8)	0.01
Average baseline diastolic blood pressure mm Hg (SD)	83.1 (11.9)	86.4 (11.7)	0.002

[a]Co-existing conditions included diabetes mellitus, peripheral artery disease, left ventricular hypertrophy, coronary artery bypass surgery, stroke, chronic kidney disease, heart failure, angina, and myocardial infarction.

Table 2

Average time of health activities provided by primary care physicians and pharmacists per patient over six months

	Average time for provider activities (SD) (minutes)					
	Primary care physicians			Pharmacists		
	Control group (N = 244)	Intervention group (N = 252)	P-Value	Control group (N = 244)	Intervention group (N = 252)	P-Value
Direct-Patient Care						
Provider visits	36.66 (34.13)	33.17 (33.19)	0.25	0.29 (2.35)	46.91 (16.15)	<0.001
Pharmacist phone calls	-	-	-	0	2.23 (1.99)	<0.001
Discussions about starting new drugs	3.49 (6.64)	3.88 (6.48)	0.51	0.07 (0.76)	14.33 (11.80)	<0.001
Discussions about increasing doses	2.14 (4.02)	1.46 (3.28)	0.04	0	4.95 (6.29)	<0.001
Discussions about decreasing doses	0.15 (0.98)	0.35 (1.45)	0.07	0	0.76 (2.10)	<0.001
Discussions about discontinuing drugs	0.64 (2.16)	0.78 (2.31)	0.47	0	3.28 (4.91)	<0.001
Discussions about weight reduction	1.71 (5.65)	1.98 (5.38)	0.58	0	3.93 (9.24)	<0.001
Discussions about DASH plan[b]	0.35 (3.21)	0.18 (1.17)	0.46	0	1.49 (4.92)	<0.001
Discussions about sodium restriction	0.48 (3.14)	0.65 (2.11)	0.48	0	1.43 (3.35)	<0.001
Discussions about increased physical activity	1.49 (4.44)	1.86 (4.13)	0.34	0	5.29 (8.15)	<0.001
Discussions about alcohol reduction	0.05 (0.60)	0.12 (0.94)	0.36	0	0.10 (0.91)	<0.001
Discussions about other lifestyle modifications e.g. smoking cessation	1.32 (4.21)	1.57 (3.94)	0.50	0	3.84 (6.82)	<0.001
Collaboration						
Written communication	0	15.39 (15.68)	<0.001	0	15.39 (15.68)	<0.001
Phone communication	0	0.24 (1.05)	<0.001	0	0.24 (1.05)	<0.001
Curbside consultation[c]	0	7.69 (4.72)	<0.001	0	7.69 (4.72)	<0.001
Face-to-face communication[d]	0	1.33 (3.08)	<0.001	0	1.33 (3.08)	<0.001
Arrangement by pharmacists for a physician visit on a separate scheduled appointment	-	-	-	0	1.24 (3.41)	<0.001
Total time	48.48 (47.70)	70.65 (45.79)	<0.001	0.36 (2.91)	114.45 (43.44)	<0.001

[b] Dietary Approaches to Stop Hypertension,

[c] Curbside consultation is informal face-to-face communication at any place in the clinic.,

[d] Face-to-face communication was defined as a scheduled consultation or meeting in which a pharmacist had a specific concern or a treatment plan and needed to discuss the case in more details with a physician.

Table 3

Average number of laboratory tests used per patient over six months

	Average number (SD)		P-Value
	Control (N = 187)[e]	Intervention (N= 200)[e]	
Bicarbonate	1.47 (1.55)	0.34 (0.78)	<.001
BUN (Blood Urea Nitrogen)	1.81 (1.66)	1.04 (1.15)	<.001
Calcium	1.47 (1.48)	0.74 (0.89)	<.001
Total cholesterol	0.82 (0.77)	0.58 (0.73)	0.002
CRP (C-reactive protein)	0.05 (0.28)	0	0.02
Creatinine	1.93 (1.67)	1.50 (1.44)	0.008
GFR (Glomerular filtration rate)	0.34 (0.93)	0.21 (0.63)	0.12
Glucose	1.42 (3.77)	0.96 (1.09)	0.11
HDL (High density protein)	0.81 (0.77)	0.58 (0.73)	0.003
Hematocrit	0.71 (1.42)	0.39 (0.67)	0.006
Homocysteine	0	0	-
LDL (Low density protein)	0.75 (0.69)	0.59 (0.74)	0.03
Potassium	1.90 (1.64)	1.69 (1.51)	0.19
Sodium	1.83 (1.61)	1.05 (1.14)	<.001
Triglyceride	0.80 (0.76)	0.56 (0.70)	0.001
Urine microalbumin	0.13 (0.38)	0.12 (0.34)	0.82
Total	16.22 (13.50)	10.35 (8.53)	<.001

[e]The number of observations was less because some patients did not have laboratory tests.

Table 4

Average number of antihypertensive agents and number of drug changes per patient, and drug costs per antihypertensive agent over six months

	Mean (SD)		P-value
	Control	Intervention	
Number of dose-specified antihypertensive agents	3.09 (1.82)	4.14 (2.25)	<0.001
Number of drug changes[f]	1.18 (1.58)	3.24 (2.43)	<0.001
Unadjusted drug costs per dose-specified antihypertensive agent	$109.24 (116.15)	$90.95 (65.69)	0.03
Total adjusted[g] drug costs	$287.64 (171.45)	$383.53 (171.45)	<0.001
Adjusted drug costs[g] per dose-specified antihypertensive agent	$104.92 (25.89)	$95.99 (25.89)	0.32

[f] Drug changes included starting new drugs, increasing doses, decreasing doses, and discontinuing drugs.

[g] Adjusted costs were the results from multiple regression analysis controlling for age, gender, race, marital status, smoking status, alcohol intake, number of medications at baseline, number of comorbidities at baseline, systolic blood pressure at baseline, and diastolic blood pressure at baseline.

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Table 5

Comparison of average six-month unadjusted and adjusted costs of each category

Cost Category	Mean Unadjusted Costs (SD)				Mean Adjusted Costs[h] (SD)			
	Control	Intervention	Difference[i] ($) [95% CI]	P-value	Control	Intervention	Difference ($) [95% CI]	P-value
Primary care physicians	111.20 (109.42)	151.01(104.45)	39.80 [20.94, 58.67]	<0.001	104.33(31.37)	151.93 (31.37)	47.60 [29.13, 66.06]	<0.001
Pharmacists	0.64 (5.24)	194.26 (74.89)	193.62 [184.2, 203.1]	<0.001	2.74 (11.76)	192.36 (11.76)	189.62 [180.07, 199.17]	<0.001
Primary care physicians and pharmacists	111.84 (109.86)	345.26 (144.00)	233.42 [210.8, 256.1]	<0.001	107.07 (38.26)	344.29 (38.26)	237.22 [215.60, 258.85]	<0.001
Specialists[j]	9.14 (29.23)	11.36 (35.47)	2.22 [-3.51, -7.94]	0.45	8.75 (5.94)	12.15 (5.94)	3.40 [-2.29, -9.09]	0.24
All providers	120.98 (116.91)	356.62 (151.86)	235.64 [211.8, 259.5]	<0.001	115.82 (41.70)	356.44 (41.70)	240.62 [217.76, 263.48]	<0.001
Labs	44.16 (52.67)	33.26 (35.10)	-10.89 [-18.82, -2.97]	0.01	42.28 (16.61)	34.93 (16.61)	-7.35 [-15.02, -0.32]	0.06
Medications	322.64 (289.60)	350.61 (280.48)	27.97 [-22.32, 78.26]	0.28	287.64 (171.45)	383.53 (171.45)	95.89 [53.23, 138.55]	<0.001
Total costs	487.78 (351.89)	740.49 (346.08)	252.71 [191.1, 314.3]	<0.001	445.75 (194.00)	774.90 (194.00)	329.16 [275.50, 382.82]	<0.001

[h]Adjusted costs were the results from multiple regression analysis controlling for age, gender, race, marital status, smoking status, alcohol intake, number of medications at baseline, number of comorbidities at baseline, systolic blood pressure at baseline, and diastolic blood pressure at baseline.

[i]The difference is the difference in values between the intervention group and the control group.

[j]Specialists referred to cardiologists or nephrologists.