Clinical Trials

Cost-Effectiveness of a Physician–Pharmacist Collaboration Intervention to Improve Blood Pressure Control

Linnea A. Polgreen, Jayoung Han, Barry L. Carter, Gail P. Ardery, Christopher S. Coffey, Elizabeth A. Chrischilles, Paul A. James

See Editorial Commentary, pp 1106–1107

Abstract—Previous studies have demonstrated the cost-effectiveness of physician–pharmacist collaborations to improve hypertension control. However, most studies have limited generalizability, lacking minority and low-income populations. The Collaboration Among Pharmacist and Physicians to Improve Blood Pressure Now (CAPTION) trial randomized 625 patients from 32 medical offices in 15 states. Each office had an existing clinical pharmacist on staff. Pharmacists in intervention offices communicated with patients and made recommendations to physicians about changes in therapy. Demographic information, blood pressure (BP), medications, and physician visits were recorded. In addition, pharmacists tracked time spent with each patient. Costs were assigned to medications and pharmacist and physician time. Cost-effectiveness ratios were calculated based on changes in BP measurements and hypertension control rates. Thirty-eight percent of patients were black, 14% were Hispanic, and 49% had annual income <$25 000. At 9 months, average systolic BP was 6.1 mm Hg lower (±3.5), diastolic was 2.9 mm Hg lower (±1.9), and the percentage of patients with controlled hypertension was 43% in the intervention group and 34% in the control group. Total costs for the intervention group were $1462.87 (±132.51) and $1259.94 (±183.30) for the control group, a difference of $202.93. The cost to lower BP by 1 mm Hg was $33.27 for systolic BP and $69.98 for diastolic BP. The cost to increase the rate of hypertension control by 1 percentage point in the study population was $22.55. Our results highlight the cost-effectiveness of a clinical pharmacy intervention for hypertension control in primary care settings. (Hypertension. 2015;66:1145-1151. DOI: 10.1161/HYPERTENSIONAHA.115.06023.)

Key Words: blood pressure ■ cost-benefit analysis ■ hypertension ■ pharmacists ■ therapy

An estimated 29% of adults are hypertensive.1–3 In the United States, hypertension has the greatest risk of all-cause mortality of any modifiable risk factor1 and is the most common cause of cardiovascular deaths worldwide.4 Antihypertensive therapies reduce the risk of strokes, kidney and heart disease, and mortality.5 Furthermore, these therapies are cost effective.6,7

Lifelong therapy for hypertension is usually required and represents one of the most common reasons patients take medications chronically.1 However, the initiation of therapy is often not sufficient to establish effective blood pressure (BP) control. Patients need to be monitored at regular intervals over time, and titration of medication is often needed.1 Despite widespread treatment of hypertension, only 50% of patients with hypertension achieve BP control and poor control has been documented for the past several decades.8–11

Patients diagnosed with hypertension are not optimally treated for a variety of reasons. First, inadequate control can be caused by clinical inertia: physicians may be reluctant to add drugs or increase dosages.12–14 For example, 1 study showed that in patients with documented evidence of >6 months of uncontrolled hypertension, BP medications were started or changed only 38% of the time.15 In addition, physicians’ busy clinical workloads and patients with multiple other symptomatic complaints can distract the physician and patients, preventing achievement of effective BP control.16 Finally, poor hypertension control can result from poor adherence to prescribed therapy on the part of patients who may fail to take the medication or take it intermittently.17

Team-based care has been shown to be effective for improving BP control.18–22 Teams with nurses or pharmacists have improved BP control, but the strongest evidence is with pharmacists.20,21 A recent review showed that interventions involving pharmacists resulted in average decreases of 7.6 mm Hg in systolic and 3.9 mm Hg in diastolic BP.23 However, questions about the generalizability and cost-effectiveness of these interventions remain. The Collaboration Among Pharmacist and Physicians to Improve Outcomes Now (CAPTION) trial was designed to implement pharmacist–physician collaboration in primary care offices among diverse populations of patients.22
The purpose of this study is to examine the cost-effectiveness of the intervention implemented in the CAPTION trial.

Methods

Data Sources

The main results from the CAPTION trial have previously been published.23 The study included 32 medical offices in 15 states. Randomization occurred at the medical-office level (ie, all subjects in each medical office were in the same study arm), and offices were stratified based on the number of minority patients and their score on our pharmacy-structure survey.24 Offices were randomized to 1 of 3 groups: a 9-month BP intervention, a 24-month BP intervention, or usual care. The intervention was designed to be identical in the 2 intervention groups for the first 9 months. The primary end point was BP control at 9 months, and this period was used in the present analyses. This study was approved by the University of Iowa Institutional Review Board and the Institutional Review Boards affiliated with each medical office. All subjects provided written informed consent.

Patients were included if they spoke either English or Spanish, were aged at least 18 years, and had uncontrolled hypertension defined as BP >140 mm Hg systolic or >90 mm Hg diastolic. For patients with diabetes mellitus or chronic kidney disease, these cut offs were >130 and >80 mm Hg, respectively, based on recommendations from the 7th report of the Joint National Committee on Prevention, Detection, and Treatment of High Blood Pressure.25

A study coordinator used or affiliated with each office recruited subjects and collected data. The study coordinator measured BP in the sitting position after appropriate rest using standard research technique at baseline, 6, and 9 months.26 At least 3 BP measurements were taken using an automated device. The initial value was not used. Two subsequent BPs were obtained a minute apart and were averaged if they were within 4 mm Hg. If >4 mm Hg different, a fourth BP was obtained and the 2 closest values were averaged using the African American Study of Kidney Disease trial procedures.27 The study coordinator collected the following at baseline: height, weight, pulse, the duration of hypertension, the presence of other cardiovascular risk factors, symptoms and adverse drug reactions, sociodemographics, comorbidities, current antihypertensive medications, and dose.

The intervention involved a medical record review by the pharmacist and an initial patient interview, including (1) a medication history; (2) an assessment of knowledge of BP medications, dosages and timing, and potential side effects; and (3) other barriers to BP control (eg, side effects and nonadherence). Lifestyle modifications were discussed as well when appropriate.28 The remaining intervention included a telephone call from the pharmacist at 2 weeks, structured face-to-face visits between patients and pharmacists at baseline, 1, 2, 4, 6, and 8 months, and additional visits if BP remained uncontrolled. This implementation trial did not require strict adherence to this protocol, but all pharmacist visits were tracked. The pharmacist created a care plan and made recommendations to the physician to adjust therapy.19,29 Because the pharmacists worked in the medical offices, most pharmacist–physician communication was face to face. Physicians were free to accept, reject, or modify any recommendation. Recommendations to patients focused on medication education, improving adherence, and strategies to implement lifestyle modifications.

After 9 months of this intervention, average systolic BP was 6.1 mm Hg lower (±3.5), diastolic was 2.9 mm Hg lower (±1.9), and hypertension control was 43% in the intervention group and 34% in the control group. Adverse events were uncommon, and there were no overall differences in the frequency of subjects reporting any serious events among the intervention and control groups.

Measures

Provider Time

The perspective of this cost analysis is society in general. For each patient encounter, pharmacists recorded the number of minutes spent

Results

The Figure displays the distribution of subjects in this study. Analysis includes 625 patients: there were 401 patients in the
intervention group and 224 in the control group. The mean age was 61 years (±1.01). A majority of patients were women (60.3%), but minorities were well represented: 38.4% were blacks, and 14.2% were Hispanic or Latino. Nearly half of patients were diagnosed with diabetes mellitus (47.7%), and one fourth of patients were diagnosed with hyperlipidemia (26.1%). Nearly half of patients received a post high school education (47.0%) and were married (46.9%). The majority of patients (84.2%) had insurance coverage: the most common sources of coverage were private insurance (38.6%), Medicare (30.2%), and Medicaid (13.9%). Low-income patients were well represented, with 22.9% of patients earning <$10,000 in household income annually. The only statistically significant differences between groups were seen for percent married (P=0.030) and type of insurance coverage (P<0.0001).

We previously reported an average of 4.9 BP-medication changes for 9 months for intervention patients. Patients in the usual care group averaged 1.1 BP-medication changes (P=0.0003).

Table 1 presents descriptive statistics of patient-specific costs. There were 3302 prescriptions for baseline antihypertensive agents where dose, strength, and drug name information were available. Patient-specific drug costs for the entire 9-month period ranged from $2.12 to $12,341.19 (mean: $1196.08±101.67), and 9 patients were taking no medications. The mean total drug cost per patient was slightly higher in the intervention groups but not significantly so: $1239.1 (±6.18) per patient on average in the intervention group and $1146.27 (±11.85) in the control group (P=0.7848). However, the patients in the intervention group had more of their medications changed during the course of the study, and this resulted in significantly higher costs for changed hypertension medications: $272.45 (±64.39) per patient in the intervention group and $170.75 (±51.63) in the control group (P=0.0352). Therefore, the cost differential for medications to provide this intervention for 9 months was $101.70 compared with the usual care group.

The pharmacists had 2036 encounters for 360 patients for a 9-month period. The total time each patient spent with the pharmacist ranged from 15 to 1044 minutes, with an average of 155 minutes, resulting in an average of $140.62 (±10.66) in pharmacist costs per patient. There were 439 patients who had at least 1 visit with a physician in the medical office, and the maximum number of physician visits per patient was 36. A larger percentage of subjects in the control group had a

![Figure](http://hyper.ahajournals.org/)
physician visit (82% versus 64%), and the median number of visits for the control group was higher (3 versus 2 per subject). This resulted in lower average costs for physician visits in the intervention group ($98.34±13.76 versus $113.67±16.72), but these costs are not statistically significant (P=0.1774).

Total costs, which are the sum of drug costs, physician time, and pharmacist costs, ranged from $8.48 to $13074.64, and 5 patients had no costs during the study period. Mean total costs were $1462.87 (±132.51) in the intervention group and $1259.94 (±183.30) in the control group. Thus, the total additional cost to provide the intervention for 9 months compared with usual care was $202.93.

Compared with the control group, the cost to lower BP by 1 mm Hg was $202.93/6.1=$33.27 for systolic BP and $202.93/2.9=$69.98 for diastolic BP. Comparing rates in the intervention and control groups, the cost to increase BP control by 1 percentage point was $202.93/9.0=$22.55.

We performed a sensitivity analysis and included only those patients who completed the 9-month intervention. The results of this analysis are given in Table 2. Five-hundred thirty-nine patients were included, and these costs were slightly lower than those for the full sample (eg, a few patients with high drug costs did not have a 9-month visit). However, the difference between the costs in the intervention groups and the control group was slightly higher than that in the full sample. For those with a 9-month visit, the cost to lower BP by 1 mm Hg was $236.8/6.1=$38.82 for systolic and $236.8/2.9=$81.66 for diastolic. Comparing rates in the intervention and control groups, the cost to increase BP control by 1 percentage point was $236.8/9.0=$26.31. Because AWP tend to overstate drug prices, our second sensitivity analysis used deflated drug costs, and the results are shown in Table 3. Total drug costs fell to $328.27 (±29.3) in the intervention group and $291.97 (±41.33) in the control group. Subsequently, total costs fell to $559.80 (±36.40) in the intervention group and $558.27 (±55.82) for diastolic. The cost to increase BP control by 1 percentage point was $161.88/9.0=$17.99.

Discussion

Our results demonstrate that a pharmacist–physician collaborative intervention specifically designed to use existing clinical pharmacists located in primary care offices was effective. Pharmacists spent ≈2 hours with patients for a 9-month period of time. This additional pharmacist care resulted in statistically and clinically significant reductions in BP compared with the control group.

A criticism of previous physician–pharmacist BP interventions is related to their generalizability to nonresearch practice settings. A major strength of the CAPTION trial was that patients with complex medical problems and primary care providers caring for patients with lower socioeconomic status were specifically recruited to help ensure that the results were more generalizable. In fact, 38% of the patients were blacks, and 23% of all patients had annual household income <$10,000. Almost half of the population was diabetic, and many patients had multiple morbidities. Previous physician–pharmacist BP interventions are related to their generalizability to nonresearch practice settings. A major strength of the CAPTION trial was that patients with complex medical problems and primary care providers caring for patients with lower socioeconomic status were specifically recruited to help ensure that the results were more generalizable. In fact, 38% of the patients were blacks, and 23% of all patients had annual household income <$10,000. Almost half of the population was diabetic, and many patients had multiple morbidities. Previous physician–pharmacist BP interventions.

Table 1. Cost Comparison*

<table>
<thead>
<tr>
<th>Variable</th>
<th>All Subjects (n=625)</th>
<th>Intervention (n=401)</th>
<th>Control (n=224)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changed hypertension medications</td>
<td>236</td>
<td>579.12</td>
<td>272.45</td>
<td>657.9</td>
</tr>
<tr>
<td>Hypertension medications</td>
<td>960.08</td>
<td>1055.27</td>
<td>951.46</td>
<td>933.53</td>
</tr>
<tr>
<td>Total drug cost</td>
<td>1196.08</td>
<td>1296.85</td>
<td>1223.91</td>
<td>63.14</td>
</tr>
<tr>
<td>Pharmacist cost</td>
<td>90.22</td>
<td>110.28</td>
<td>140.62</td>
<td>108.93</td>
</tr>
<tr>
<td>Physician cost</td>
<td>103.83</td>
<td>136.16</td>
<td>98.34</td>
<td>140.54</td>
</tr>
<tr>
<td>Total cost</td>
<td>1390.14</td>
<td>1372.81</td>
<td>1462.87</td>
<td>1353.86</td>
</tr>
</tbody>
</table>

*All costs are in US dollars.

Table 2. Cost Comparison, Sensitivity Analysis—Only Patients Who Completed the 9-Month Intervention*

<table>
<thead>
<tr>
<th>Variable</th>
<th>All Subjects (n=539)</th>
<th>Intervention (n=345)</th>
<th>Control (n=194)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changed hypertension medications</td>
<td>218.54</td>
<td>460.89</td>
<td>251.3</td>
<td>493.2</td>
</tr>
<tr>
<td>Hypertension medications</td>
<td>849.95</td>
<td>886.10</td>
<td>856.9</td>
<td>828.8</td>
</tr>
<tr>
<td>Total drug cost</td>
<td>1068.49</td>
<td>1045.14</td>
<td>1108.2</td>
<td>1013.1</td>
</tr>
<tr>
<td>Pharmacist cost</td>
<td>91.86</td>
<td>106.70</td>
<td>143.5</td>
<td>101.8</td>
</tr>
<tr>
<td>Physician cost</td>
<td>94.20</td>
<td>99.65</td>
<td>88.02</td>
<td>105.1</td>
</tr>
<tr>
<td>Total cost</td>
<td>1254.55</td>
<td>1089.34</td>
<td>1339.8</td>
<td>1064.8</td>
</tr>
</tbody>
</table>

This analysis only includes those subjects who had complete data at 9-months.

*All costs are in US dollars.
interventions have relied on small numbers of intervention providers and few clinics or medical offices. In contrast, this study included 26 intervention pharmacists, many of whom had worked in the medical offices for >10 years. Our results will help health systems determine cost-effective strategies to implement value-based population-health strategies encouraged by the Affordable Care Act, insurers and employers.

In this study, we found the cost of the intervention to be relatively modest. With a small amount of time spent by the pharmacist, ≈2 hours for a 9-month period of time, significant reductions in BP were observed. Specifically, we observed a decrease in BP of 6.1 mm Hg systolic (±3.5) and 2.9 mm Hg diastolic (±1.9; Table 4). Without considering economies of scale or positive spillovers, if we extrapolate these findings, adding a pharmacist to a medical office that does not currently use one could result in improvements for many hypertensive patients. Specifically, a pharmacist who works 40 hours per week and sees each patient for 2 hours every 9 months could manage 720 hypertensive patients in collaboration with physicians. An unexpected finding was that the intervention group had fewer physician visits, thus saving physician time for other, more complex patient health problems. With insufficient primary care providers to care for the population, this study demonstrates that pharmacist–physician collaboration can improve care while allowing primary care physicians to focus on other important medical issues.

Our study has several limitations. First, our results may not be generalizable to other practice settings. But given the pragmatic nature of our study (using existing medical office personnel) and the oversampling of subjects in groups traditionally under-represented in trials, the results of the CAPTION trial are more generalizable than previous physician–pharmacist interventions. Not all primary care medical offices have an onsite clinical pharmacist, and this limits the extent to which this work can be implemented. Second, our cost estimation did not account for overhead or interruptions to clinic workflow, and we did not measure the opportunity cost of the pharmacist. If the time spent with patients was easy to incorporate into the pharmacist’s day, the costs of this study would be lower than estimated. If pharmacists neglected other duties while attending the patients in this study, the costs could be higher. In busy practices, space for meeting with patients or making confidential calls may be scarce, making this intervention more difficult to implement. In addition, because all the medical offices in this study employed pharmacists, patients in the control group might have spent time with the pharmacist as well. These costs were not included. Also, we did not calculate patient time in this study: the number of visits per patient was nontrivial and would have resulted in substantial costs for some patients. Third, patients were enrolled in this study for 24 months. We chose to use only 9 months for this study because the 2 intervention arms were the same for the first 9 months and because this time point was used for the primary outcome in the CAPTION trial. Also, this time point allowed us to maximize the number of subjects that we could include in our analysis. Although costs continued to accrue for these patients, some patients’ BP did not continue to improve. Thus, costs to sustain this type of intervention would probably be higher than reported here.

Fourth, we used retail drug prices, which, because of insurance, are probably not the costs for most patients in this study (out-of-pocket payments plus insurance payments). However, this leads to overestimates in both the intervention and control groups and should not bias our results. Fifth, our investigation focused only on hypertension and did not investigate

### Table 3. Cost Comparison, Sensitivity Analysis Using Deflated Drug Costs*

<table>
<thead>
<tr>
<th>Variable</th>
<th>All Subjects (n=539) Mean (SD)</th>
<th>Intervention (n=345) Mean (SD)</th>
<th>Control(n=194) Mean (SD)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changed hypertension medications</td>
<td>45.13 (95.43)</td>
<td>51.74 (102.24)</td>
<td>33.39 (80.87)</td>
<td>0.032</td>
</tr>
<tr>
<td>Hypertension medications</td>
<td>270.06 (250.12)</td>
<td>276.52 (240.50)</td>
<td>258.58 (266.62)</td>
<td>0.425</td>
</tr>
<tr>
<td>Total drug cost</td>
<td>315.00 (283.80)</td>
<td>328.27 (277.65)</td>
<td>291.97 (293.72)</td>
<td>0.152</td>
</tr>
<tr>
<td>Pharmacist cost</td>
<td>91.86 (106.70)</td>
<td>143.5 (101.8)</td>
<td>0 (0)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Physician cost</td>
<td>94.20 (99.65)</td>
<td>88.02 (105.1)</td>
<td>105.2 (88.34)</td>
<td>0.055</td>
</tr>
<tr>
<td>Total cost</td>
<td>501.26 (344.79)</td>
<td>559.80 (344.92)</td>
<td>397.15 (319.87)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

*All costs are in US dollars.

---

### Table 4. BP Results

<table>
<thead>
<tr>
<th>Cost Category</th>
<th>Intervention Mean (SD), n=401</th>
<th>Control Mean (SD), n=224</th>
<th>Difference Between Intervention and Control Groups</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline systolic BP</td>
<td>148.9 (14.8)</td>
<td>149.7 (15.3)</td>
<td>−0.8</td>
<td>0.5135</td>
</tr>
<tr>
<td>Baseline diastolic BP</td>
<td>85.1 (12.1)</td>
<td>84.3 (12.6)</td>
<td>+0.8</td>
<td>0.4341</td>
</tr>
<tr>
<td>9-mo systolic BP</td>
<td>131.6 (15.8)</td>
<td>138.2 (19.7)</td>
<td>−6.1</td>
<td>0.0005</td>
</tr>
<tr>
<td>9-mo diastolic BP</td>
<td>76.3 (11.1)</td>
<td>78.0 (14.5)</td>
<td>−2.9</td>
<td>0.0026</td>
</tr>
<tr>
<td>9-mo BP control</td>
<td>43%</td>
<td>34%</td>
<td>+9%</td>
<td>0.052</td>
</tr>
</tbody>
</table>

BP indicates blood pressure.
other health outcomes. However, the effect of our intervention could result in positive spillover effects: pharmacist attention to hypertension could lead to improvements in other areas of a patient’s health. Finally, our outcome was cost per decrease in millimeter of mercury of BP, not quality-adjusted-life years, which is the standard outcome in cost-effectiveness analyses. Unfortunately, we could not calculate quality-adjusted-life years for this study because we did not collect long-term outcomes for the patients in this study.

Despite our limitations, we are confident that the effect of the intervention is clinically meaningful. Although a 6.1-mm Hg reduction may seem small from a numeric standpoint, it is clinically meaningful if it can be sustained. An analysis of 30 clinical trials demonstrated that a 5-mm Hg difference in systolic BP for 3 to 5 years reduces the risk of all cardiovascular complications and stroke by 25% to 30%. Hypertension is responsible for an estimated 395,000 deaths per year in the United States, many of which could be prevented with better BP control. Future efforts should consider reduction in morbidity and mortality that follow the treatment effects we observed in the CAPTION trial. Such estimates must, of course, make assumptions on future BP control after the cessation of the intervention.

Perspectives
This study demonstrated the low cost of expanding a pharmacist–physician collaborative hypertension intervention. Previous studies have shown that similar interventions using research personnel are cost effective. However, the CAPTION trial is more pragmatic in nature and demonstrates cost-effectiveness in a broader patient population. Our results highlight the cost-effectiveness of clinical pharmacists in primary care settings when increased attention is being focused on value-based care.

Sources of Funding
This study was supported by the National Heart, Lung, and Blood Institute (RO1HL091841, RO1HL091843, and K25HL122305).

Disclosures
None.

References
What Is New?

- This study used clinic-based pharmacists rather than research personnel.
- The study population had a relatively large percentage of minority and low-income patients.

What Is Relevant?

- This study demonstrated the cost-effectiveness of using onsite clinic-based pharmacists to help control hypertension.

Novelty and Significance

Summary

Our results highlight the cost-effectiveness of clinical pharmacists for hypertension control in primary care settings: the cost to increase hypertension control by 1 percentage point was $22.55. The cost to lower blood pressure by 1 mmHg was $38.82 for systolic and $81.66 for diastolic.
Cost-Effectiveness of a Physician–Pharmacist Collaboration Intervention to Improve Blood Pressure Control

Linnea A. Polgreen, Jayoung Han, Barry L. Carter, Gail P. Ardery, Christopher S. Coffey, Elizabeth A. Chrischilles and Paul A. James

*Hypertension*. 2015;66:1145-1151; originally published online November 2, 2015; doi: 10.1161/HYPERTENSIONAHA.115.06023

*Hypertension* is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2015 American Heart Association, Inc. All rights reserved.
Print ISSN: 0194-911X. Online ISSN: 1524-4563

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://hyper.ahajournals.org/content/66/6/1145

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in *Hypertension* can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to *Hypertension* is online at:
http://hyper.ahajournals.org//subscriptions/