Economics of Team-Based Care for Blood Pressure Control: Updated Community Guide Systematic Review

Verughese Jacob, PhD, MPH, MS,[1] Jeffrey A. Reynolds, MPH,[1] Sajal K. Chattopadhyay, PhD,[1]
Keith Nowak, MPH,[2] David P. Hopkins, MD, MPH,[1] Erika Fulmer, MHA,[3] Ami N. Bhatt, DrPH, MPH,[3,4]
Nicole L. Therrien, PharmD, MPH,[3] Alison E. Cuellar, PhD,[5] Thomas E. Kottke, MD, MSPH,[6]
John M. Clymer, BA,[7] Kimberly J. Rask, MD, PhD[8] the Community Preventive Services Task Force

Introduction: This paper examined the recent evidence from economic evaluations of team-based care for controlling high blood pressure.

Methods: The search covered studies published from January 2011 through January 2021 and was limited to those based in the U.S. and other high-income countries. This yielded 35 studies: 23 based in the U.S. and 12 based in other high-income countries. Analyses were conducted from May 2021 through February 2023. All monetary values reported are in 2020 U.S. dollars.

Results: The median intervention cost per patient per year was $438 for U.S. studies and $299 for all studies. The median change in healthcare cost per patient per year after the intervention was −$140 for both U.S. studies and for all studies. The median net cost per patient per year was $439 for U.S. studies and $133 for all studies. The median cost per quality-adjusted life year gained was $12,897 for U.S. studies and $15,202 for all studies, which are below a conservative benchmark of $50,000 for cost-effectiveness.

Discussion: Intervention cost and net cost were higher in the U.S. than in other high-income countries. Healthcare cost averted did not exceed intervention cost in most studies. The evidence shows that team-based care for blood pressure control is cost-effective, reaffirming the favorable cost-effectiveness conclusion reached in the 2015 systematic review.
Am J Prev Med 2023;65(4):735−754. Published by Elsevier Inc. on behalf of American Journal of Preventive Medicine.

INTRODUCTION

High blood pressure in the U.S. was associated with $52.2 billion in annual healthcare and indirect costs during 2018−2019 and was a primary factor contributing to about 120,000 deaths in 2020.[1] High blood pressure and its related health consequences disproportionately affect African American people and people from other historically disadvantaged populations. Disparities are present in the U.S. both by race and ethnicity; and by age in the awareness, diagnosis, treatment, and control of high blood pressure.[2−4]

National Health and Nutrition Examination Survey 2015−2018 data show that 47% of adults in the U.S.

From the [1]Community Guide Program, Office of Scientific Evidence and Recommendations, Office of Science, Centers for Disease Control and Prevention, Atlanta, Georgia; [2]Marion County Public Health Department, Indianapolis, Indiana; [3]Division for Heart Disease and Stroke Prevention, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia; [4]ASRT, Inc., Atlanta, Georgia; [5]College of Health and Human Services, George Mason University, Fairfax, Virginia; [6]HealthPartners Institute, Bloomington, Minnesota; [7]National Forum for Heart Disease & Stroke Prevention, Washington, District of Columbia; and [8]Alliant Health Solutions, Atlanta, Georgia

Address correspondence to: Verughese Jacob, PhD, MPH, MS, Community Guide Program, Office of Scientific Evidence and Recommendations, Office of Science, Centers for Disease Control and Prevention, 1600 Clifton Road, Mailstop H21-8, Atlanta GA 30329. E-mail: hir0@cdc.gov.
0749-3797/$36.00
https://doi.org/10.1016/j.amepre.2023.04.013

have *high blood pressure*, defined as systolic blood pressure (SBP) >130 mmHg or diastolic blood pressure (DBP) >80 mmHg.[5] Only a quarter of those with high blood pressure have it under control (SBP/DBP<130/ 80 mm Hg) with the help of medications and lifestyle modifications. About half of those with uncontrolled high blood pressure are under no treatment with medication.[5] The reasons for suboptimal control are varied, ranging from provider inertia to patient-level barriers and poor medication adherence.[6,7] Collaborative team-based care that includes healthcare workers in addition to primary care providers (PCPs) can improve blood pressure outcomes through greater involvement of patients in self-management, closer and more frequent monitoring of outcomes, and optimization of medication therapy.[8]

The Community Preventive Services Task Force (CPSTF)[9] reaffirmed its previous finding that team-based care interventions for control of high blood pressure were both effective[10] and cost-effective.[11] This study describes the results from the systematic review update of research published from January 2011 through January 2021 that provided the basis for the CPSTF economic findings and reaffirmation of cost-effectiveness.

METHODS

This study was conducted using established methods for systematic economic reviews developed by the Centers for Disease Control and Prevention and approved by the CPSTF.[12] The study team included subject-matter experts on cardiovascular disease (CVD) and CVD risk factors from various agencies, organizations, and academic institutions; members of the CPSTF; and experts in systematic economic reviews from the Community Guide Program at the Centers for Disease Control and Prevention. Two reviewers independently screened the search yield and abstracted information from the included studies. Unresolved disagreements between reviewers were taken to the full-review team for a majority consensus.

Team-based care to improve blood pressure control is an organizational intervention that uses a multidisciplinary team to improve the quality of care. Team-based care is established by adding new staff or changing the roles of existing staff who work with a PCP. Each team includes the patient; the patient's PCP; and other professionals such as nurses, pharmacists, dietitians, and community health workers (CHWs). Team members provide process support and share responsibilities of blood pressure control to complement the activities of the PCP. Responsibilities include medication management, patient follow-up, and medication adherence and self-management support.[13]

The study team developed an economic analytic framework identifying the intervention, population, and economic outcomes of interest.[14] The framework also identified components of each economic outcome that are drivers and components that contribute substantially to the magnitude of estimates. The following research questions were addressed by the review:

- What is the cost to implement the intervention?
- What are the economic benefits of the intervention?
- What is the intervention cost per unit reduction in SBP?
- How do intervention costs compare to economic benefits?
- What is the return on investment (ROI)?
- Is the intervention cost-effective?

The economic outcomes related to the research questions are defined below.

The components of cost to implement team-based care are labor cost of the team members, cost of time and materials for training, and the cost of any tools provided to enhance team communication. These may be combined with additional interventions, such as self-measured blood pressure monitoring. All these components are considered drivers of intervention cost.

The effectiveness of the intervention is measured in terms of reduction in SBP. Intervention cost per unit reduction in SBP is a useful metric to measure what it costs to achieve a unit of effectiveness. SBP is chosen because it is the blood pressure outcome most frequently reported in studies.

Team-based care may increase healthcare costs in the short term through increased contacts with providers and increased prescription and use of medications. Improvements in blood pressure control and other risk factors for CVD such as type 2 diabetes mellitus (T2DM) and hyperlipidemia addressed by team-based care will lead to reduced cardiovascular morbidity and mortality. Reduced morbidity will lead to reductions in outpatient visits, inpatient stays, medications, and emergency department (ED) visits. Therefore, effective interventions are expected to avert healthcare costs in the long term, producing negative values for estimates of change in healthcare costs. Consequently, all components of healthcare cost (e.g., outpatient visits, ED) are considered drivers of its magnitude.

Net cost is the sum of intervention costs and changes in healthcare costs. ROI is the ratio of the difference between averted healthcare cost and intervention cost, to intervention cost and is generally expressed as a percentage. ROI takes a health systems perspective because the intervention cost is assumed to be borne by a healthcare payer and because the only benefit considered is averted healthcare cost. Net cost becomes negative and favorable when averted healthcare cost exceeds intervention cost, which also implies a positive and favorable ROI.

Cost benefit is expressed as the ratio of economic benefits to intervention cost. Both benefits and costs are measured in monetary terms and are constituted from a societal perspective, where all costs and benefits are considered regardless of who pays and who benefits.

Improved blood pressure control will prevent CVD events and increase both the quantity and quality of years lived. Economic evaluations generally measure this outcome as quality-adjusted life years (QALYs) gained or disability-adjusted life years (DALYs) averted.

Reduced morbidity and mortality leads to greater productivity of patients at their work sites owing to both increased number of work hours and increased output per work hour. Productivity is considered a driver of economic benefits because of the intervention.

Cost-effectiveness is the net cost per QALY gained or the net cost per DALY averted. The CPSTF considers an intervention to be cost-effective when the net cost per QALY gained ≤$50,000[15] or the net cost per DALY averted is less than or equal to the per capita gross domestic product of the relevant country.[16] The $50,000 per QALY gained benchmark for cost-effectiveness is very conservative, given that it was first introduced some decades ago and persists in the literature without adjustment for inflation or economic growth.[12]

A tool for quality assessment of economic evidence was developed for the scope of this study and is available as Appendix Materials (available online). Two raters used the tool to independently assign and later reconcile points that indicate limitations in the quality of the estimates for variables related to intervention cost, healthcare cost, QALY, and net cost per QALY gained. Each estimate was scored as good, fair, or limited in quality of capture on the basis of inclusion of components deemed to be drivers of magnitude for the estimate. Each estimate also was scored as good, fair, or limited in quality of measurement on the basis of the appropriateness of analysis and methods used to derive the estimate. The final quality score for an estimate is the lower of the quality assessed for capture and quality assessed for measurement. The quality score assigned to an estimate that is a combination of other estimates such as net cost is the lower of the quality scores assigned to its parts, intervention cost and change in healthcare cost estimates. Estimates that received a limited quality score were removed from further consideration.

Although CPSTF systematic economic review methods recommend a societal perspective for outcomes, evaluations of team-based care interventions might take a health systems perspective because these interventions are generally implemented in healthcare settings. Estimates for healthcare cost or QALY that are summed over values from multiple years must be discounted to present values, and sensitivity analysis must be conducted for modeled estimates that are based on assumed model input values. These expectations, among others, for the ideal conduct of economic evaluations were built into the tool for quality assessment of estimates.

All monetary values in the results and discussion sections are in 2020 U.S. dollars, adjusted for inflation using the Consumer Price Index from the Bureau of Labor Statistics[17] and converted from foreign currency denominations using consumption purchasing power parities from the World Bank.[18] Estimates are presented in per patient per year (PPPY) terms, wherever possible. Summaries of estimates are reported as medians for continuous variables (along with IQIs when there are ≥4 estimates) and as frequencies for categorical variables. All analyses were conducted using Microsoft Excel during May 2021 through February 2023.

A search of the peer-reviewed literature was conducted with the following inclusion criteria: met the definition of the intervention, conducted in a high-income country according to World Bank criteria,[19] written in English, and included ≥1 economic outcomes described in the research questions. Studies that implemented team-based care for CVD risk factors such as hyperlipidemia or T2DM were included if blood pressure was a criterion in patient selection or if blood pressure outcomes were reported. The search was conducted in Medline, CINAHL, Cochrane, and EconLit for papers published from January 2011 through January 2021.

Reference lists in included studies were screened, and subject-matter experts were consulted for additional studies. The detailed search strategy is available on The Community Guide website.[13]

RESULTS

Figure 1 shows the search yield for the economic review that resulted in 35[20−54] included studies, providing information on intervention cost (29 studies),[20,21,23−30,32−38,40−43,45−49,51,52,54] change in healthcare cost (16 studies),[20,21,23,24,28−31,33,34,37,39,40,51,52,54] net cost (17 studies),[20,21,23,24,28−30,33,34,37,40,44,50−54] and cost-effectiveness (14 studies).[22−24,27,29,30,35,36,40,41,43,47,51,53] There were no cost-benefit studies. Studies are presented in alphabetical order within tables, beginning with studies based in the U.S. Table 1 provides intervention and population characteristics. There were 23 studies based in the U.S.[20,21,24,27,28,30−32,34−36,39−42,44−49,53,54]; 4 based in the United Kingdom[23,29,43,52]; 2 each based in Argentina,[22,33] Canada,[37,51] and China (Hong Kong)[25,26]; and 1 each based in Australia[38] and Singapore.[50] The study designs were RCTs (15 studies),[20−23,25,28,33,40,46,49−54] studies modeled on the basis of RCTs (8 studies),[24,29,30,35,37,43,44,47] pre-to-post studies with comparison groups (9 studies),[26,31,34,36,38,39,41,42,48] cross-sectional studies (2 studies),[32,45] or a study modeled with inputs from a review of the literature (1 study).[27]

The median sample size was 261 for U.S. studies and 200 for non-U.S. studies. The median length of intervention was 12 months. Among all studies, the settings were primary care clinic (26 studies)[20,21,23,24,27−30,32,35,36,38−48,50−52,54]; hospital clinic (2 studies)[25,26]; public health clinic (2 studies)[22,33]; worksite wellness (2 studies)[31,34]; pharmacy (1 study)[49]; ED (1 study)[53]; and mixed setting (1 study).[37] The median age of patients in U.S. studies was 58 years (IQI=54−60 years), with 57% female, whereas the median age in non-U.S studies was older at 61 years (IQI=56−67 years), with smaller female representation at 48%. For studies based in the U.S., the median percentage of patients from historically disadvantaged racial and ethnic populations was 53% (IQI=13%−90%). Study populations were urban (22 studies),[21−26,28,29,33,35−37,39,41,42,47,49−54] rural (1 study),[32] urban−rural mixture (8 studies),[20,27,31,34,38,40,44,48] and 4 studies not reporting location.[30,43,45,46]

High blood pressure was defined as SBP/DBP ≥140/90 mmHg (≥130/80 for patients with T2DM), and treatments were targeted to reduce blood pressure to below those thresholds in most studies. The exceptions were 3 studies,[28,43,52] which set the goal to be 5 mmHg lower for home-based blood pressure measurements. The median reduction in mmHg of SBP was 6.2 (IQI=4.5−8.6) mmHg across all studies (Table 1).[21,22,24,25,27−30,33,35−37,40−44,46,49−52,54]
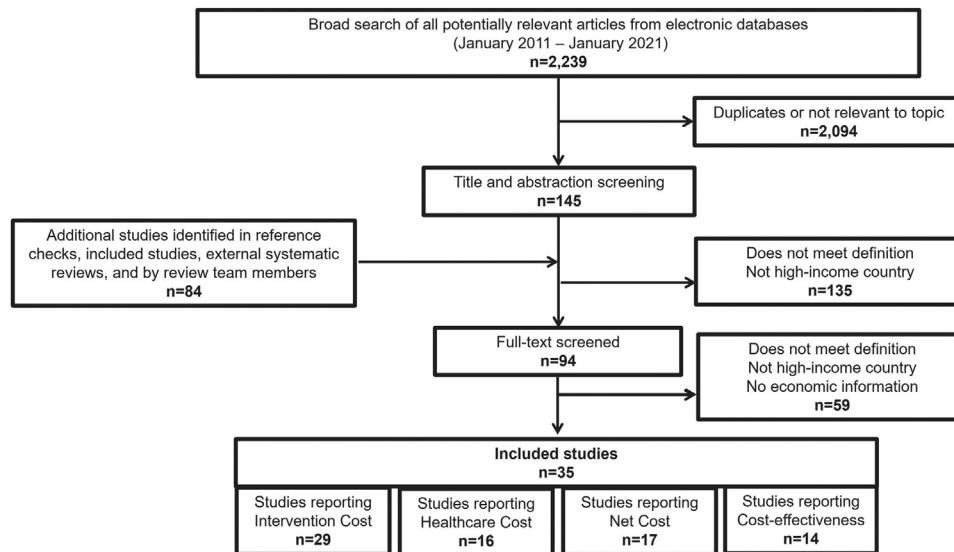
Figure 1. Search yield

Of the 35 included studies, 29[20−24,27−39,41−46,48,49,52−54] had a focus on blood pressure control, and others had hypertension as a patient baseline condition with other conditions such as depression (1 study),[40] dyslipidemia (1 study),[26] and T2DM (4 studies).[25,47,50,51] Members added to the team to support the physician were pharmacist (17 studies)[24−28,30,36,37,39,41,42,44−46,49−51]; nurse (15 studies)[27,29,32,37−40,42,43,45,48,50,52−54]; medical assistant (5 studies)[32,45,48,53,54] CHW, health coach, counselor, educator, or adviser (12 studies)[20−23,29,32,33,35,39,45,47,54]; dietitian (4 studies)[36,39,50,54]; and mental health provider (2 studies).[40,48]

Table 2 shows that the number of estimates that were good (16) and fair (15) for quality of intervention cost were about the same. The most frequent reason for assignment of limitation points was failure to include the cost of training followed by failure to include the cost of communication tools. Quality of estimates for change in healthcare cost was mostly rated fair (10), and rated as good (6). The driver of healthcare costs that was most frequently missing was emergency department visits. The most frequent reasons for limitation points assigned to healthcare cost estimates included the use of healthcare utilization data for all causes rather than those related to CVD and CVD risk factors, and lack of adjustment for covariates that may impact healthcare utilization such as patient age. Table 3 shows that there were 11 good-quality estimates for net cost per QALY gained and there were 4 estimates of fair quality. The most frequent reasons for assignment of limitation points for cost-effectiveness estimates were short time horizon and the assumption of no fade-out for intervention effect.

Table 2 shows that the median intervention cost PPPY for U.S. studies was $438 (IQI=$285−$649) on the basis of 20 estimates from 19 studies.[20,21,24,27,28,30,32,34−36,40−42,45−49,54] The median intervention cost PPPY for all studies was $299 (IQI=$168−$518) on the basis of 31 estimates from 29 studies.[20,21,23−30,32−38,40−43,45−49,51,52,54]

Table 2 shows that the median reduction in mmHg of SBP was 6.3 (IQI=4.9−9.0) mmHg across all studies.[21,24,25,27−30,33,35−37,40−43,46,49,51,52,54] The median intervention cost per mmHg reduction in SBP was $47 (IQI=$31−$62) across all studies[21,24,25,27−30,33,35−37,40−43,46,49,51,52,54] and $55 (IQI=$44−$66) for studies based in the U.S.[21,24,27,28,30,35,36,40−42,46,49,54]

Of those U.S. studies reporting patient race or ethnicity and intervention cost per unit reduction in SBP,[21,28,30,35,36,40−42,46,49,54] studies with >50% of patients from historically disadvantaged populations reported a median reduction in SBP and median intervention cost per unit reduction in SBP of 6.3 (IQI=6.1−8.0) mmHg and $47 (IQI=$44−$59)[21,35,36,46,49,54] versus 10.3 (IQI=9.1−11.7) mmHg and $59 (IQI=$54−$139) for studies with majority White patients.[28,30,40−42] The median reduction in SBP and median intervention cost per unit reduction in SBP for studies of teams with pharmacists, with nurses, and with CHWs/coaches/counselors/educators/advisers were 8.9 (IQI=6.0−10.8) mmHg and $44 (IQI=$31−$58),[24,25,27,28,30,36,37,41,42,46,49,51] 5.2 (IQI=3.7−8.5) mmHg and $54 (IQI=$28−$66),[27,29,37,40,42,43,52,54] and 6.4 (IQI=6.2−6.6) mmHg and $63 (IQR=$48−$67),[21,29,33,35,54] respectively.

Table 2 shows that the median change in healthcare cost PPPY in the U.S. studies was −$140 (IQR= −$639 to $226) on the basis of 10 estimates from 10

Table 1. Intervention Characteristics, Patient Characteristics, Baseline and Change in Clinical Indicators (N=35 Studies)

Study Country Study design	Intervention sample size Setting Urbanicity Intervention duration in months	Nonphysician team members	Mean age in years Percent female Percent non-White patients	Baseline mean clinical indicators (change)	Condition focus
Adair et al. 2013[20] U.S. RCT	1,429 PC Mixed 12	CHW	61 y 50% 10%	SBP 129 (NR); DBP 75 (NR) HbA1c 7.4 (NR); LDL 86 (NR)	BP, T2DM, HF
Allen et al. 2014[21] U.S. RCT	261 PC Urban 12	CHW	54 y 72% 79%	SBP 140 (−6.2); DBP 83 (−3.1) HbA1c 8.9 (−0.5); LDL 122 (−16)	BP, Lipids, T2DM, CVD
Billups et al. 2014[24] U.S. Modeled (RCT)	175 PC Urban 6	Pharmacist	60 y 38% NR	SBP 149 [−12.5]; DBP 90 (NR) HbA1c NR (NR); LDL NR (NR)	BP
Dehmer et al. 2016[27] U.S. Modeled	Model PC Mixed 12	Nurse or Pharmacist	NR 52% NR	SBP 142 [−8.1]; DBP NR (NR) HbA1c NR (NR); LDL 120 (−11.9)	BP
Dehmer et al. 2018[28] U.S. RCT	148 PC Urban 12	Pharmacist	63 y 48% 13%	SBP 150 (−9.7); DBP 83 (−5.1) HbA1c NR (NR); LDL NR (NR)	BP
Fishman et al. 2013[30] U.S. Modeled (RCT)	261 PC NR 12	Pharmacist	59 y 56% 21%	SBP 152 (−8.9); DBP 89 (−3.6) HbA1c NR (NR); LDL NR (NR)	BP
Goetzel et al. 2013[31] U.S. Pre−post with comparison	8,609 WW Mixed 72	NR	48 y 25% NR	Higher proportion with BP control Higher proportion with cholesterol control	BP, T2DM, CVD
Halladay et al. 2017[32] U.S. Cross-sectional	1,238 PC Rural NA	Nurse, Nurse Practitioner, Medical Assistant, Informatics staff, Health coach	NR NR 52%	SBP NR (NR); DBP NR (NR) HbA1c NR (NR); LDL NR (NR)	BP
Henke et al. 2011[34] U.S. Pre−post with comparison	31,823 WW Mixed NA	NR	40 y 45% NR	SBP NR (NR); DBP NR (NR) HbA1c NR (NR); LDL NR (NR)	BP, Lipids, Weight, Tobacco
	136 PC	CHW, Health educator		SBP 141 [−6.4]; DBP 81 (NR) HbA1c NR (NR); LDL 116 (NR)	BP, T2DM

(continued on next page)

Table 1. Intervention Characteristics, Patient Characteristics, Baseline and Change in Clinical Indicators (N=35 Studies) (*continued*)

Study Country Study design	Intervention sample size Setting Urbanicity Intervention duration in months	Nonphysician team members	Mean age in years Percent female Percent non-White patients	Baseline mean clinical indicators (change)	Condition focus
Hollenbeak et al. 2014[35] U.S. Modeled (RCT)	Urban 6		61 y 70% 100%		
Hong et al. 2018[36] U.S. Pre−post with comparison	629 PC Urban 3	Dietitian, Pharmacist	60 y 58% 70%	SBP 148 (−9); DBP 86 (−4) HbA1c NR (NR); LDL NR (NR)	BP
Isetts et al. 2012[39] U.S. Pre−post with comparison	823 PC Urban 12	Pharmacist, Nurse, Health coach, Diabetes educator, Dietitian	NR 60% NR	SBP NR (NR); DBP NR (NR) HbA1c NR (NR); LDL NR (NR)	BP, Lipids, T2DM
Katon et al. 2012[40] U.S. RCT	106 PC Mixed 12	Nurse, Psychiatrist	57 y 48% 25%	SBP 136 (−3.4); DBP NR (NR) HbA1c 8.1 (−0.56); LDL 107 (−9.1)	Depression, CVD, T2DM
Kulchaitanaroaj 2015a[42] U.S. Pre−post with comparison	101 PC Urban 9	Pharmacist, Nurse	60 y 57% 12%	SBP 152 (−15.4); DBP 85 (−4.5) HbA1c NR (NR); LDL NR (NR)	BP
Kulchaitanaroaj 2015b[42] U.S. Pre−post with comparison	252 PC Urban 6	Pharmacist, Nurse	59 y 65% 10%	SBP 154 [−10.8]; DBP 87 [−5.1] HbA1c NR (NR); LDL NR (NR)	BP
Kulchaitanaroaj 2017[41] U.S. Pre−post with comparison	399 PC Urban 6	Pharmacist	57 y 57% 14%	SBP 151 (−12); DBP 87 (NR) HbA1c NR (NR); LDL NR (NR)	BP
Overwyk 2019a[44] U.S. Modeled (RCT)	Model PC Mixed 60	Pharmacist	NR 53% NR	SBP 145 (−8.5); DBP NR (NR) HbA1c NR (NR); LDL 120 (−8.1)	BP
Overwyk 2019b[44] U.S. Modeled (RCT)	Model PC Mixed 60	Pharmacist	NR 58% NR	SBP 153 (−8.5); DBP NR (NR) HbA1c NR (NR); LDL 120 (−8.1)	BP

Table 1. Intervention Characteristics, Patient Characteristics, Baseline and Change in Clinical Indicators (N=35 Studies) (*continued*)

Study Country Study design	Intervention sample size Setting Urbanicity Intervention duration in months	Nonphysician team members	Mean age in years Percent female Percent non-White patients	Baseline mean clinical indicators (change)	Condition focus
Overwyk 2019c[44] U.S. Modeled (RCT)	Model PC Mixed 60	Pharmacist	NR 59% NR	SBP 153 (−8.5); DBP NR (NR) HbA1c NR (NR); LDL 119 (−8.1)	BP
Panattoni et al. 2018[45] U.S. Cross-sectional	11,873 PC NR NA	Nurse Practitioner, Pharmacist, Medical Assistant, Health coach	58 y 48% 71%	SBP NR (NR); DBP NR (NR) HbA1c NR (NR); LDL NR (NR)	BP, T2DM
Polgreen et al. 2015[46] U.S. RCT	401 PC NR 9	Pharmacist	61 y 60% 54%	SBP 149 (−6.1); DBP 85 (−2.9) HbA1c NR (NR); LDL NR (NR)	BP
Prezio 2014[47] U.S. Modeled (RCT)	90 PC Urban 12	CHW	47 y 67% 94%	SBP 126 (NR); DBP 78 (NR) HbA1c 8.2 (−1.1); LDL 111 (NR)	T2DM
Reiss-Brennan et al. 2016[48] U.S. Pre−post with comparison	63,396 PC Mixed 48	Nurse, Medical Assistant, Mental-health provider	NR 62% 6%	Reduced odds of BP control Improved odds of quality of diabetes care	BP, T2DM, Depression
Shireman 2016[49] U.S. RCT	207 Pha Urban 6	Pharmacist, Pharmacy Technician	54 y 62% 100%	SBP 151 (−5.6); DBP 92 (−2.3) HbA1c NR (NR); LDL NR (NR)	BP
Twiner et al. 2017[53] U.S. RCT	58 ED Urban 12	HTN specialist, Nurse Practitioner, Physician Assistant	49 y 65% 95%	SBP 151 (NR); DBP 97 (NR) HbA1c NR (NR); LDL NR (NR)	BP
Wagner et al. 2016[54] U.S. RCT	224 PC Urban 12	Nurse, Medical Assistant, Health coach, Dietitian	53 y 55% 93%	SBP 158 (−8.6); DBP NR (NR) HbA1c 9.8 (−1.2); LDL 146 (−27.9)	T2DM, BP, Lipids
Augustovski et al. 2018[22] Argentina RCT	743 PH Urban 18	CHW	56 y 53% NA	SBP 152 (−5.3); DBP 92 (−5.1) HbA1c NR (NR); LDL NR (NR)	BP
	72 PC	CHW		SBP NR (NR); DBP NR (NR) HbA1c NR (NR); LDL NR (NR)	BP, Lipids, T2DM, Weight, Tobacco

Table 1. Intervention Characteristics, Patient Characteristics, Baseline and Change in Clinical Indicators (N=35 Studies) (*continued*)

Study Country Study design	Intervention sample size Setting Urbanicity Intervention duration in months	Nonphysician team members	Mean age in years Percent female Percent non-White patients	Baseline mean clinical indicators (change)	Condition focus
Barton et al. 2012[23] United Kingdom RCT	Urban 3		53 y 59% NA		
Chan et al. 2012[25] China, Hong Kong RCT	51 HC Urban 9	Pharmacist	63 y 41% NA	SBP 141 (−3.3); DBP 75 (−2.1) HbA1c 9.7 (−1.2); LDL 101 (−12.8)	T2DM
Chung et al. 2011[26] China, Hong Kong Pre−post with comparison	150 HC Urban 24	Pharmacist	56 y 55% NA	SBP NR (NR); DBP NR (NR) HbA1c NR (NR); LDL 137 (−18.9)	Lipids
Dixon et al. 2016[29] United Kingdom Modeled (RCT)	325 PC Urban 12	Health advisor, Nurse	67 y 20% NA	SBP 148 (−2.7); DBP 81 (NR) HbA1c NR (NR); LDL NR (0)	BP, Weight, Tobacco
He et al. 2017[33] Argentina RCT	743 PH Urban 18	CHW	56 y 53% NA	SBP 152 (−6.6); DBP 92 (−5.3) HbA1c NR (NR); LDL NR (NR)	BP
Houle et al. 2012[37] Canada Modeled (RCT)	115 Various Urban 6	Pharmacist, Nurse	66 y 35% NA	SBP 143 (−5.6); DBP 76 (−2.1) HbA1c NR (NR); LDL NR (NR)	BP
Iles et al. 2014[38] Australia Pre−post with comparison	120 PC Mixed 12	Nurse	69 y 49% NA	SBP NR (NR); DBP NR (NR) HbA1c NR (NR); LDL NR (NR)	T2DM, BP, CVD
Monahan 2019a[43] United Kingdom Modeled (RCT)	395 PC NR 12	Nurse	67 y 46% NA	SBP 153 (−3.5); DBP 85 (−1.5) HbA1c NR (NR); LDL NR (NR)	BP
Monahan 2019b[43] United Kingdom Modeled (RCT)	393 PC NR 12	Nurse	67 y 47% NA	SBP 153 ([−4.7); DBP 86 (−1.3) HbA1c NR (NR); LDL NR (NR)	BP

Table 1. Intervention Characteristics, Patient Characteristics, Baseline and Change in Clinical Indicators (N=35 Studies) (*continued*)

Study Country Study design	Intervention sample size Setting Urbanicity Intervention duration in months	Nonphysician team members	Mean age in years Percent female Percent non-White patients	Baseline mean clinical indicators (change)	Condition focus
Siaw et al. 2017[50] Singapore RCT	214 PC Urban 6	Pharmacist, Nurse, Dietitian	59 y 48% NA	SBP 129 (−3.8); DBP NR (NR) HbA1c 8.6 (−0.5); LDL NR (NR)	T2DM
Simpson et al. 2015[51] Canada RCT	131 PC Urban 12	Pharmacist	57 y 59% NA	SBP 130 (−6.0); DBP 75 (−1.0) HbA1c 7.0 (−0.02); LDL 91 (−0.77)	T2DM
Stoddart et al. 2013[52] United Kingdom RCT	200 PC Urban 6	Nurse	61 y 42% NA	SBP 146 (−4.3); DBP 87 (−2.3) HbA1c NR (NR); LDL NR (NR)	BP
Summary for U.S studies Median (IQI) OR Frequency	Sample size 261 (155−1,134) Setting HC 0; PC 19; PH 0; Pha 1; various 0; WW 2 Duration 12 (6−16)	Pharmacist 15; Nurse 10; Dietitian 3; CHW, Coach, counselor, educator or adviser 8; Medical Assistant 5; Mental-health Provider 2	Age 58 y (54 y to 60 y) Percent female 57% (50% to 62%) Percent non-White 53% (13% to 90%)	SBP 150 (142 to 152) (−8.5 [−9.0 to −6.2]) DBP 86 (83 to 89) (−3.8 [−4.7 to −3.1]) HbA1c 8.2 (8.1 to 8.9) (−0.8 [−1.1 to −0.5]) LDL 120 (112 to 120) (−9.1 [−14.0 to −8.1])	BP 24, HF 1, Depression 3, Lipids 4, T2DM 10, CVD 2, Weight 1, Tobacco 1
Summary for non-U.S. studies Median (IQI) OR Frequency	Sample size 200 (120−393) Setting HC 2; PC 7; PH 2; Pha 0; various 1; WW 0 Duration 12 (6−12)	Pharmacist 5; Nurse 7; Dietitian 1; CHW, Coach, counselor, educator or adviser 4; Medical Assistant 0; Mental-health Provider 0	Age 61 y (56 y to 67 y) Percent female 48% (42% to 53%) Percent non-White NA	SBP 147 (142 to 152) (−4.5 [−5.5 to −3.6]) DBP 85 (76 to 87) (−2.1 [−3.0 to −1.5]) HbA1c 8.6 (7.8 to 9.2) (−0.5 [−0.9 to −0.3]) LDL 101 (96 to 119) (−12.8 [−15.9 to −6.8])	BP 9, HF 0, Depression 0, Lipids 2, T2DM 5, CVD 1, Weight 2, Tobacco 2
Summary for all studies Median (IQI) OR Frequency	Sample size 252 (134−686) Setting HC 2; PC 26; PH 2; Pha 1; various 1; WW 2 Duration 12 (6−12)	Pharmacist 20; Nurse 17; Dietitian 4; CHW, coach, counselor, educator or adviser 126; Medical Assistant 5; Mental-health Provider 2	Age 59 y (56 y to 61 y) Percent female 54% (48% to 59%) Percent non-White NA	SBP 149 (141 to 152) (−6.2 [−8.6 to −4.5]) DBP 85 (81 to 88) (−3.0 [−4.7 to −2.1]) HbA1c 8.4 (7.9 to 9.1) (−0.6 [−1.2 to −0.5]) LDL 119 (107 to 120) (−10.5 [−15.2 to −8.1])	BP 33, HF 1, Depression 3, Lipids 6, T2DM 15, CVD 3, Weight 4, Tobacco 3

Note: HbA1c is in percentage, DBP is in mmHg, mean LDL is in mg/dL, and mean SBP is in mmHg.
BP, high blood pressure; CHW, community health worker; CVD, cardiovascular disease; DBP, diastolic blood pressure; ED, emergency department; HC, hospital clinic; HF, heart failure; LDL, low-density lipoprotein; NA, not applicable; NR, not reported; PC, primary care clinic; PH, public health clinic; Pha, Pharmacy; SBP, systolic blood pressure; T2DM, type 2 diabetes mellitus; WW, worksite wellness; y, year.

studies.[20,21,24,28,30,31,34,39,40,54] Across all the studies, the median change in healthcare cost PPPY was −$140 (IQI= −$386 to $30) on the basis of 16 estimates from 16 studies.[20,21,23,24,28−31,33,34,37,39,40,51,52,54] Across all studies, the median change in healthcare cost PPPY coded with causes associated with CVD or CVD risk factors was −$48 (IQI= −$172 to $59).[21,24,28−31,33,37,51,52,54] Across all studies that measured healthcare cost associated with all causes (all diseases and risk factors), the median change in healthcare cost PPPY was −$684 (IQI= −$813 to −$167).[20,23,34,39,40]

Net cost is measured as the sum of the change in healthcare cost after the intervention and the cost of the intervention. A negative value indicates that averted healthcare cost exceeds intervention cost. Estimates of net cost are shown in Table 3. The median net cost PPPY for U.S. studies was $439 (IQI=$34−$821) on the basis of 12 estimates from 10 studies,[20,21,24,28,30,34,40,44,53,54] and the median across all studies was $133 (IQI= −$16 to $495) on the basis of 19 estimates from 17 studies.[20,21,23,24,28−30,33,34,37,40,44,50−54] The net cost estimates were a mixture of negative and positive values, with 5 studies[20,34,37,50,51] showing that averted healthcare cost exceeded intervention cost and 12 studies[21,23,24,28−30,33,40,44,52−54] showing that intervention cost exceeded averted healthcare cost. Across all studies, the median net cost coded with causes associated with CVD or CVD risk factors was $371 (IQI=$87−$508).[21,24,28−30,33,37,51,52,54]

The net cost for U.S. studies with the majority of patients from historically disadvantaged populations were $751[21] and $408[54] compared with a median of $784 (IQR= −$751 to $1,326)[20,27,30,40] for studies with majority White patients. For all studies, the median net cost for studies of teams with pharmacists, with nurses, and with CHWs/coaches/counselors/educators/advisers were $470 (IQI= −$63 to $520),[24,28,30,37,51] $334 (IQI=$133−$408),[29,37,40,52,54] and $221 (IQR=$87−$383),[20,21,23,29,33,54] respectively.

Table 3 shows that the median ROI for U.S. studies was −90% (IQI= −160% to −30%) on the basis of 8 estimates from 8 studies[20,21,24,28,30,34,40,54] and was −80% (IQI= −130% to 20%) for all studies on the basis of 14 estimates from 14 studies.[20,21,23,24,28−30,33,34,37,40,51,52,54] A positive value of ROI indicates a favorable economic outcome in terms of cost savings from a healthcare systems perspective. As in the case of net cost, the ROI estimates indicate that the evidence is mixed in terms of favoring the intervention from the perspective of a healthcare system. Across all studies, the median ROI of healthcare costs associated with CVD or CVD risk factors was −90% (IQI= −140% to −70%).[21,24,28−30,33,37,51,52,54]

Table 3 shows that the median net cost per QALY gained reported in U.S. studies was $12,897 (IQI=$3,300−$43,760) on the basis of 9 estimates from 9 studies,[24,27,30,35,36,40,41,47,53] with 6 estimates of good quality[24,27,30,35,40,41] and 3 of fair quality.[36,47,53] The median net cost per QALY gained reported in all studies was $15,202 (IQI=$3,569−$34,509) on the basis of 15 estimates from 14 studies.[22−24,27,29,30,35,36,40,41,43,47,51,53] There were no studies that reported cost per DALY averted. Only 2 studies[27,29] included averted costs of productivity losses when calculating the cost-effectiveness ratios, indicating that the cost-effectiveness evidence is predominantly from a health system perspective.

The median cost per QALY gained reported in U.S. studies with hypertension as the focus was $12,897 (IQR=$3,470−$45,051) on the basis of 7 estimates from 7 studies,[24,27,30,35,36,41,53] and for all studies, it was $14,049 (IQI=$3,605−$31,141) on the basis of 12 estimates from 11 studies.[22−24,27,29,30,35,36,41,43,53]

The mean cost per QALY gained for U.S. studies with the majority of patients from historically disadvantaged populations was $37,912 (range=$12,897−$57,078)[35,36,47] versus $17,815 (range=$2,276−$$48,856)[30,40,41] for studies with majority White patients. For all studies, the median cost per QALY gained for studies of teams with pharmacists, with nurses, and with CHWs/coaches/counselors/educators/advisers were $14,912 (IQI=$3,385−$43,188)[24,27,30,36,41,51]; $12,354 (IQI=$3,300−$15,202)[27,29,40,43]; and $18,981 (IQR=$14,626−$28,010),[23,29,35,47] respectively.

DISCUSSION

The economic evidence shows that team-based care interventions to control blood pressure are cost-effective on the basis of a cost-effectiveness benchmark of $50,000. Intervention cost was higher in U.S. studies than in studies in other high-income countries. Intervention cost per unit change in SBP varied by the composition of the care team and by the race and ethnicity of the study population in U.S. studies. Healthcare cost averted was greater in U.S. studies than in studies in other high-income countries. Net cost and ROI showed mixed results on whether averted healthcare costs exceeded the cost of intervention.

On the basis of the median reduction in SBP (8.5 mmHg for U.S. studies) and the median intervention cost ($438 PPPY for U.S. studies) found in this review, team-based care for blood pressure control can have a substantial population-level impact. An indication of the impact is provided by the study by Dehmer et al.,[27] which found team-based care to be highly cost-effective at $3,300 per QALY gained when modeled for the U.S.

Table 2. Intervention Cost, Healthcare Cost, and Intervention Cost per Unit Reduction in SBP

Study Country	Nonphysician team members Percentage non-White patients	Intervention sample size Intervention duration in months	Intervention cost per patient per year (quality of estimate)	Drivers included in intervention cost	Change in healthcare cost per patient per year (quality of estimate)	Drivers included in healthcare cost	Change in SBP in mmHg	Intervention cost per mmHg reduction in SBP (quality of estimate)
Adair et al. 2013[20] U.S.	CHW 10%	1,429 12	$323 (Good)	L, T, CT	$4,740[a] (Fair)	OP, IP, ED	NR	NR
Allen et al. 2014[21] U.S.	CHW 79%	261 12	$299 (Fair)	L	$452 (Fair)	OP, Med	−6.2	$48 (Fair)
Billups et al. 2014[24] U.S.	Pharmacist NR	175 6	$219 (Fair)	L	$302 (Good)	OP, IP, ED, Med	−12.5	$17 (Fair)
Dehmer et al. 2016[27] U.S.	Nurse, Pharmacist NR	Model 12	$1,002 (Good)	L, T, CT	NR	NA	−8.1	$124 (Good)
Dehmer et al. 2018[28] U.S.	Pharmacist 13%	148 12	$1,602 (Good)	L, CT	$506 (Good)	OP, IP, Med	−9.7	$165 (Good)
Fishman et al. 2013[30] U.S.	Pharmacist 21%	261 12	$470 (Good)	L, T	$0 (Good)	OP, IP, ED	−8.9	$53 (Good)
Goetzel et al. 2013[31] U.S.	NR NR	8,609 72	NR	NA	$146 (Fair)	OP, IP, ED, Med	NR	NR
Halladay et al. 2017[32] U.S.	Nurse, Nurse Practitioner, Medical Assistant, Informatics staff, Health coach 52%	1,238 NA	$65 (Good)	L, T, CT	NR	NA	NR	NR
Henke et al. 2011[34] U.S.	NR NR	31,823 Existing program	$363 (Good)	L, CT	$684[a] (Fair)	OP, IP, Med	NR	NR
Hollenbeak et al. 2014[35] U.S.	CHW, Health educator 100%	136 6	$857 (Good)	L, T	NR	NA	−6.4	$67 (Good)
Hong et al. 2018[36] U.S.	Pharmacist, Dietitian 70%	629 3	$405 (Good)	L, T	NR	NA	−9.0	$45 (Good)
Isetts et al. 2012[39] U.S.	Pharmacist, Nurse, Health coach, Diabetes educator, Dietitian NR	823 15	NR	NR	$813[a] (Fair)	OP, IP, Med	NR	NR
Katon et al. 2012[40] U.S.	Nurse, Psychiatrist 25%	106 12	$1,481 (Good)	L, CT	$532[a] (Good)	OP, IP	−3.4	$436 (Good)
Kulchaitanaroaj 2015a[42] U.S.	Nurse, Pharmacist 12%	101 9	$581 (Fair)	L	NR	NA	−15.4	$38 (Fair)
Kulchaitanaroaj 2015b[42] U.S.	Nurse, Pharmacist 10%	252 6	$626 (Fair)	L	NR	NA	−10.8	$58 (Fair)
Kulchaitanaroaj 2017[41] U.S.	Pharmacist	399 6	$718 (Fair)	L	NR	NA	−12.0	$60 (Fair)

Table 2. Intervention Cost, Healthcare Cost, and Intervention Cost per Unit Reduction in SBP (*continued*)

Study Country	Nonphysician team members Percentage non-White patients	Intervention sample size Intervention duration in months	Intervention cost per patient per year (quality of estimate)	Drivers included in intervention cost	Change in healthcare cost per patient per year (quality of estimate)	Drivers included in healthcare cost	Change in SBP in mmHg	Intervention cost per mmHg reduction in SBP (quality of estimate)
Panattoni et al. 2018[45] U.S.	Nurse Practitioner, Pharmacist, Medical Assistant, Health coach 71%	11,873 NA	$212 (Fair)	L	NR	NA	NR	NR
Polgreen et al. 2015[46] U.S.	Pharmacist 54%	401 9	$301 (Fair)	L	NR	NA	−6.1	$37 (Fair)
Prezio 2014[47] U.S.	CHW 94%	90 12	$492 (Fair)	L	NR	NA	NR	NR
Reiss-Brennan et al. 2016[48] U.S.	Nurse, Medical Assistant, mental-health provider 6%	63,396 48	$215 (Fair)	L, CT	NR	NA	NR	NR
Shireman 2016[49] U.S.	Pharmacist, Pharmacy Technician 100%	207 6	$243 (Good)	L, CT	NR	NA	−5.6	$44 (Good)
Wagner et al. 2016[54] U.S.	Nurse, Medical Assistant, Health coach, Dietitian 93%	224 12	$543 (Good)	L, T, CT	$134 (Good)	OP, IP, ED, Med	−8.6	$63 (Good)
Barton et al. 2012[23] United Kingdom	CHW NA	72 3	$475 (Fair)	L, T	$167[a] (Fair)	OP, IP, Med	NR	NR
Chan et al. 2012[25] China, Hong Kong	Pharmacist NA	51 9	$102 (Fair)	L	NR	NA	−3.3	$31 (Fair)
Chung et al. 2011[26] China, Hong Kong	Pharmacist NA	150 24	$154 (Fair)	L	NR	NA	NR	NR
Dixon et al. 2016[29] United Kingdom	Nurse, Health Advisor NA	325 12	$181 (Good)	L, T, CT	$48 (Fair)	OP, IP, Med	−2.7	$67 (Good)
He et al. 2017[33] Argentina	CHW NA	743 18	$81 (Good)	L, T, CT	$9 (Fair)	OP, IP, Med	−6.6	$12 (Good)
Houle et al. 2012[37] Canada	Nurse, Pharmacist NA	115 12	$135 (Fair)	L	$198 (Fair)	IP	−5.6	$24 (Fair)
Iles et al. 2014[38] Australia	Nurse NA	120 12	$100 (Fair)	L	NR	NA	NR	NR
Monahan 2019a[43] United Kingdom	Nurse NA	395 12	$22 (Good)	L, CT	NR	NA	−3.5	$6 (Good)
Monahan 2019b[43] United Kingdom	Nurse NA	393 12	$60 (Good)	L, CT	NR	NA	−4.7	$13 (Good)
Simpson et al. 2015[51] Canada	Pharmacist NA	131 12	$188 (Fair)	L	$346 (Fair)	OP, IP, ED, Med	−6.0	$31 (Fair)
Stoddart et al. 2013[52] United Kingdom	Nurse NA	200 6	$216 (Good)	L, CT	$118 (Good)	OP, IP, Med	−4.3	$50 (Good)

Table 2. Intervention Cost, Healthcare Cost, and Intervention Cost per Unit Reduction in SBP (*continued*)

Study Country	Nonphysician team members Percentage non-White patients	Intervention sample size Intervention duration in months	Intervention cost per patient per year (quality of estimate)	Drivers included in intervention cost	Change in healthcare cost per patient per year (quality of estimate)	Drivers included in healthcare cost	Change in SBP in mmHg	Intervention cost per mmHg reduction in SBP (quality of estimate)
Summary for U.S. studies Median (IQI) OR Frequency	Pharmacist 12; Nurse 9; CHW 4; Dietitian 3; Coach, counselor, educator or adviser 5; Medical Assistant 4; Mental-health provider 2 Percent non-White patients 52% (13% to 79%)	Sample size 261 (175 to 1,238) Duration 12 (6 to 12)	$438 ($285 to $649) Good 11, fair 9	L 20, T 7, CT 9	$140 (−$639 to $226) Good 5 fair 5	OP 10, IP 9, ED 5, Med 7	−8.8 (−10.5 to −6.2)	$55 ($44 to $66) Good 8 fair 6
Summary for non-U.S. studies Median (IQI) OR Frequency	Pharmacist 4; Nurse 6; CHW 2; Dietitian 0; Coach, counselor, educator or adviser 1; Medical Assistant 0; Mental-health provider 0 NA	Sample size 150 (118 to 359) Duration 12 (8 to 12)	$135 ($91 to $185) Good 5, fair 6	L 11, T-3, CT 5	$108 (−$190 to −$19) Good 1, fair 5	OP 5, IP 6, ED 1, Med 5	−4.5 (−5.7 to −3.5)	$28 ($13 to $36) Good 5 fair 3
Summary for all studies Median (IQI) OR Frequency	Pharmacist 16; Nurse 15; CHW 6; Dietitian 3; Coach, counselor, educator or adviser 6; Medical Assistant 4; Mental health provider 2 NA	Sample size 257 (135 to 658) Duration 12 (6 to 12)	$299 ($168 to $518) Good 16, fair 15	L 31, T 10, CT 14	$140 (−$386 to $30) Good 6, fair 10	OP 15, IP 15, ED 6, Med 12	−6.3 (−9.0 to −4.9)	$47 ($31 to $62) Good 13 fair 9

[a]Healthcare cost from all causes includes costs beyond those for hypertension, CVD risk factors, and CVD.

CHW, community health worker; CT, communication tools; CVD, cardiovascular disease; ED, emergency department; IP, inpatient; IQI, interquartile interval; L, labor; Med, medication; NA, not applicable; NR, not reported; OP, outpatient; SBP, systolic blood pressure; T, training.

Table 3. Summary Economic Outcomes: Net Cost, ROI, and Cost-Effectiveness

Study Country	Nonphysician team members Percentage non-White patients	Intervention effectiveness Baseline (change)	Change in net cost[a] per patient per year (quality of estimate)	ROI[b] Health systems perspective (quality of estimate)	Net cost per QALY gained Time horizon (quality of estimate)
Adair et al. 2013[20] U.S.	CHW 10%	SBP 129 (NR); DBP 75 (NR) HbA1c 7.4 (NR); LDL 86 (NR)	$4,417[c] (Fair)	1,370%[c] (Fair)	NR
Allen et al. 2014[21] U.S.	CHW 79%	SBP 140 (−6.2); DBP 83 (−3.1); HbA1c 8.9 (−0.5); LDL 122 (−16)	$751 (Fair)	−250% (Fair)	NR
Billups et al. 2014[24] U.S.	Pharmacist NR	SBP 149 (−12.5); DBP 90 (NR); HbA1c NR (NR); LDL NR (NR)	$520 (Fair)	−240% (Fair)	$3,641 Lifetime (Good)
Dehmer et al. 2016[27] U.S.	Nurse or Pharmacist NR	SBP 142 (−8.1); DBP NR (NR); HbA1c NR (NR); LDL 120 (−11.9)	NR	NR	$3,300 10 years (Good)
Dehmer et al. 2018[28] U.S.	Pharmacist 13%	SBP 150 (−9.7); DBP 83 (−5.1); HbA1c NR (NR); LDL NR (NR)	$1,097 (Good)	−70% (Good)	NR
Fishman et al. 2013[30] U.S.	Pharmacist 21%	SBP 152 (−8.9); DBP 89 (−3.6); HbA1c NR (NR); LDL NR (NR)	$470 (Good)	−100% (Good)	$2,314 Lifetime (Good)
Henke et al. 2011[34] U.S.	NR NR	No clinical outcomes reported	$321[c] (Fair)	90%[c] (Fair)	NR
Hollenbeak et al. 2014[35] U.S.	CHW, Health educator 100%	SBP 141 (−6.4); DBP 81 (NR); HbA1c NR (NR); LDL 116 (NR)	NR	NR	$12,897 10 years (Good)
Hong et al. 2018[36] U.S.	Pharmacist, Dietitian 70%	SBP 148 (−9); DBP 86 (−4); HbA1c NR (NR); LDL NR (NR)	NR	NR	$57,078 15 years (Fair)
Isetts et al. 2012[39] U.S.	Nurse, Pharmacist, Health coach, Diabetes educator, Dietitian NR	No clinical outcomes reported	NR	NR	NR
Katon et al. 2012[40] U.S.	Nurse, Psychiatrist 25%	SBP 136 (−3.4); DBP NR (NR); HbA1c 8.1 (−0.56); LDL 107 (−9.1)	$2,013[c] (Good)	−140%[c] (Good)	$2,276 2 years (Good)
Kulchaitanaroaj 2017[41] U.S.	Pharmacist 14%	SBP 151 (−12); DBP 87 (NR); HbA1c NR (NR); LDL NR (NR)	NR	NR	$48,856 10 years (Good)

(continued on next page)

Table 3. Summary Economic Outcomes: Net Cost, ROI, and Cost-Effectiveness (*continued*)

Study Country	Nonphysician team members Percentage non-White patients	Intervention effectiveness Baseline (change)	Change in net cost[a] per patient per year (quality of estimate)	ROI[b] Health systems perspective (quality of estimate)	Net cost per QALY gained Time horizon (quality of estimate)
Overwyk 2019a[44] U.S.	Pharmacist NR	SBP 145 (−8.5); DBP NR (NR); HbA1c NR (NR); LDL 120 (−8.1)	$73 (Fair)	NR	NR
Overwyk 2019b[44] U.S.	Pharmacist NR	SBP 153 (−8.5); DBP NR (NR); HbA1c NR (NR); LDL 120 (−8.1)	$35 (Fair)	NR	NR
Overwyk 2019c[44] U.S.	Pharmacist NR	SBP 153 (−8.5); DBP NR (NR); HbA1c NR (NR); LDL 119 (−8.1)	$32 (Fair)	NR	NR
Prezio 2014[47] U.S.	CHW 94%	SBP 126 (NR); DBP 78 (NR) HbA1c 8.2 (−1.1); LDL 111 (NR)	NR	NR	$43,760 10 years (Fair)
Twiner et al. 2017[53] U.S.	HTN specialist, Nurse Practitioner, Physician Assistant 95%	SBP 151 (NR); DBP 97 (NR) HbA1c NR (NR); LDL NR (NR)	$1,032 (Fair)	NR	$41,245 1 year (Fair)
Wagner et al. 2016[54] U.S.	Nurse, Medical Assistant, Health coach, Dietitian 93%	SBP 158 (−8.6); DBP NR (NR); HbA1c 9.8 (−1.2); LDL 146 (−27.9)	$408 (Good)	−80% (Good)	NR
Augustovski et al. 2018[22] Argentina	CHW NA	SBP 152 (−5.3); DBP 92 (−5.1); HbA1c NR (NR); LDL NR (NR)	NR	NR	$3,497 18 months (Good)
Barton et al. 2012[23] United Kingdom	CHW NA	No clinical outcomes reported	$308[c] (Fair)	−60%[c] (Fair)	$22,760 1 year (Fair)
Dixon et al. 2016[29] United Kingdom	Health advisor, Nurse NA	SBP 148 (−2.7); DBP 81 (NR); HbA1c NR (NR); LDL NR (NR)	$133 (Fair)	−70% (Fair)	$15,202 1 year (Good)
He et al. 2017[33] Argentina	CHW NA	SBP 152 (−6.6); DBP 92 (−5.3); HbA1c NR (NR); LDL NR (NR)	$72 (Fair)	−90% (Fair)	NR
Houle et al. 2012[37] Canada	Nurse, Pharmacist NA	SBP 143 (−5.6); DBP 76 (−2.1); HbA1c NR (NR); LDL NR (NR)	$63 (Fair)	50% (Fair)	NR
Monahan 2019a[43] United Kingdom	Nurse NA	SBP 153 (−3.5); DBP 85 (−1.5); HbA1c NR (NR); LDL NR (NR)	NR	NR	$12,354 10 years (Good)

(continued on next page)

Table 3. Summary Economic Outcomes: Net Cost, ROI, and Cost-Effectiveness (*continued*)

Study Country	Nonphysician team members Percentage non-White patients	Intervention effectiveness Baseline (change)	Change in net cost[a] per patient per year (quality of estimate)	ROI[b] Health systems perspective (quality of estimate)	Net cost per QALY gained Time horizon (quality of estimate)
Monahan 2019b[43] United Kingdom	Nurse NA	SBP 153 (−4.7); DBP 86 (−1.3); HbA1c NR (NR); LDL NR (NR)	NR	NR	$27,773 10 years (Good)
Siaw et al. 2017[50] Singapore	Nurse, Pharmacist, Dietitian NA	SBP 129 (−3.8); DBP NR (NR); HbA1c 8.6 (−0.5); LDL NR (NR)	$198 (Fair)	NR	NR
Simpson et al. 2015[51] Canada	Pharmacist NA	SBP 130 (−6.0); DBP 75 (−1.0); HbA1c 7.0 (−0.02); LDL 2.4 (−0.02)	$158 (Fair)	80% (Fair)	$26,184 12 months (Good)
Stoddart et al. 2013[52] United Kingdom	Nurse NA	SBP 146 (−4.3); DBP 87 (−2.3); HbA1c NR (NR); LDL NR (NR)	$334 (Good)	−150% (Good)	NR
Summary for U.S. studies Median (IQI) OR Frequency	Pharmacist 10; Nurse 5; CHW 4; Dietitian 3; Coach, counselor, educator or adviser 3; Medical Assistant 2; Mental-health provider 1 Percent non-White patients 70% (18% to 94%)	SBP 149 (140 to 151) [−8.5 (−8.9 to −6.4)] DBP 85 (82 to 89) (−3.8 [−4.3 to −3.5]) HbA1c 8.2 (8.1 to 8.9) (−0.8 [−1.1 to −0.5]) LDL 120 (112 to 120) (−9.1 [−14.0 to −8.1])	$439 ($34 to $821) Good 4, fair 8	−90% (−160% to −30%) Good 4, fair 4	$12,897 ($3,300 to $43,760) Good 6, fair 3
Summary for non-U.S. studies Median (IQI) OR Frequency	Pharmacist 3; Nurse 6; CHW 3; Dietitian 1; Coach, counselor, educator or adviser 1; Medical Assistant 0; Mental-health Provider 0 NA	SBP 148 (143 to 152) (−4.7 [−5.6 to −3.8]) DBP 86 (80 to 88) (−2.1 [−3.7 to −1.4]) HbA1c 7.8 (7.4 to 8.2) (−0.3 [−0.4 to −0.1]) LDL NA	$72 (−$111 to $221) Good 1, fair 6	−70% (−90% to 20%) Good 1, fair 5	$18,981 ($13,066 to $25,328) Good 5, fair 1
Summary for all studies Median (IQI) OR Frequency	Pharmacist 13; Nurse 11; CHW 7; Dietitian 4; Coach, counselor, educator or adviser 4; Medical Assistant 2; Mental-health provider 1 NA	SBP 148 (141 to 152) (−6.3 [−8.5 to −4.4]) DBP 86 (81 to 89) (−3.1 [−4.6 to −1.8]) HbA1c 8.2 (7.8 to 8.8) (−0.5 [−1.0 to −0.5]) LDL 119 (109 to 120) (−8.6 [−12.9 to −8.1])	$133 (−$16 to $495) Good 5, fair 14	−80% (−130% to 20%) Good 5, fair 9	$15,202 ($3,569 to $34,509) Good 11, fair 4

Note: HbA1c is in percentage, DBP is in mmHg, LDL is in mg/dL, and SBP is in mmHg.
[a]Net cost = intervention cost + change in healthcare cost.
[b]ROI=(averted healthcare cost − intervention cost)/intervention cost.
[c]Healthcare cost from all causes includes costs beyond those for hypertension, CVD risk factors, and CVD.
CHW, community health worker; CVD, cardiovascular disease; DBP, diastolic blood pressure; IQI, interquartile interval; LDL, low-density lipoprotein; NR, not reported; QALY, quality-adjusted life year; ROI, return on investment; SBP, systolic blood pressure.

population, with intervention cost of $1,002 and SBP reduction of 9.7 as inputs.

Comparing the results from the previous review (on the basis of studies published from 1981 through 2012 and monetary values converted to 2020 U.S dollars)[11] with those from this review (on the basis of studies published from 2011 through 2019), the median reduction in mmHg of SBP increased from 4.5 to 6.3, and the median intervention cost per patient decreased from $353 to $299. The median intervention cost per patient per unit reduction in SBP fell from $108 in the previous review to $47 in this review because intervention cost per patient decreased, whereas intervention effectiveness in reducing SBP increased during the period between the 2 reviews. Intervention costs in this review could be lower because the larger intervention groups allowed fixed costs to be spread over more patients, with a median of 252 patients in this review versus a median of 149 patients in the previous review. The greater effectiveness of the intervention in this review could be because of the higher baseline SBP, with a median of 149 mmHg in this review versus a median of 143 mmHg in the previous review. Other explanations could be the greater attention to SBP by studies in this review, improved integration of team-based care in health systems,[4] increased effectiveness and use of generic[55,56] and fixed-dose medications,[57,58] and greater guidelines-driven treatment.[59,60] The median change in healthcare cost was −$140 in this review versus $81 in the previous review. It is unclear why there is greater healthcare cost averted in this review. One explanation may be the greater blood pressure reductions leading to better health outcomes. There were 3 studies reporting cost-effectiveness in the previous review ranging from $5,653 to $119,573 per QALY, whereas there are 14 in this review reporting a median of $15,202.

Intervention costs and outcomes varied by team composition and geographic location of studies. Teams that included pharmacists produced the greatest reduction in SBP and at the lowest cost per unit reduction, followed by teams that included nurses. Teams that included CHWs, health coaches, advisers, or educators produced less reduction in SBP and at a higher cost per unit reduction; the higher cost may be attributable to additional staff required for oversight. The intervention cost to achieve a unit reduction in SBP was lower for U.S. studies that drew its patients substantially from historically disadvantaged populations. Median change in healthcare cost in the U.S. studies was higher than that in studies outside the U.S., possibly reflecting that healthcare costs are higher in the U.S. than in other high-income countries.[61]

Team-based care interventions reduced blood pressure and other clinical outcomes related to T2DM and hyperlipidemia. Improvements in clinical outcomes beyond blood pressure may have occurred even in studies focused on hypertension simply because of greater patient contacts and contacts with a variety of providers.

Favorable clinical outcomes did not translate to reductions in healthcare costs in 5 studies.[21,24,30,40,52] Potential explanations are the short duration between baseline and follow-up (6−12 months) or the increase in the medication and outpatient components of healthcare utilization and cost.

Limitations

A limitation of this study is that summary statistics are reported across studies with very heterogeneous interventions, differing by type of team member, setting, and team organization and by populations served. None of the studies were conducted from a societal perspective that fully accounted for the value of patient time and productivity. Furthermore, studies differed in their inclusion of components that are expected to drive the magnitude of estimates for intervention costs and healthcare costs. Many studies that reported change in healthcare cost based their estimates on healthcare utilization owing to all causes and not specific to CVD or CVD risk factors. With only 1 study providing evidence for exclusively rural populations, there is a gap in evidence whether team-based care interventions can be successfully implemented in rural settings. Some studies did not report patient health outcomes (e.g., blood pressure, cholesterol) against which to gauge the change in healthcare cost. The lack of reporting for estimates of components of healthcare cost in many studies meant that their contribution to the magnitude of change in healthcare cost could not be determined.

CONCLUSIONS

The systematic economic review found that team-based care interventions for blood pressure control are cost-effective on the basis of a median estimate of $12,897 per QALY gained for U.S. studies and $15,202 per QALY gained for all studies, which are below a conservative $50,000 benchmark.

ACKNOWLEDGMENTS

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

No external support was used to fund this systematic review.

No financial disclosures were reported by the authors of this paper.

CREDIT AUTHOR STATEMENT

SUPPLEMENTAL MATERIAL

Supplemental materials associated with this article can be found in the online version at https://doi.org/10.1016/j. amepre.2023.04.013.

REFERENCES

1. Tsao CW, Aday AW, Almarzooq ZI, et al. Heart disease and stroke Statistics-2023 update: A report from the American Heart Association. *Circulation.* 2023;147(8):e93–e621. https://doi.org/10.1161/CIR.0000000000001123.
2. Muntner P, Hardy ST, Fine LJ, et al. Trends in blood pressure control among US adults with hypertension, 1999−2000 to 2017 −2018. *JAMA.* 2020;324(12):1190–1200. https://doi.org/10.1001/jama.2020.14545.
3. Muntner P, Miles MA, Jaeger BC, et al. Blood pressure control among US adults, 2009 to 2012 through 2017 to 2020. *Hypertension.* 2022;79(9):1971–1980. https://doi.org/10.1161/HYPERTENSIONAHA.122.19222.
4. U.S. Department of Health and Human Services. The Surgeon General's Call to Action to Control Hypertension. Washington, DC: U.S. Department of Health and Human Services, Office of the Surgeon General, 2020. Accessed October 20, 2022.
5. Centers for Disease Control and Prevention (CDC). Hypertension cascade: hypertension prevalence, treatment and control estimates among US adults aged 18 years and older applying the criteria from the American College of Cardiology and American Heart Association's 2017 hypertension guideline—NHANES 2015−2018. Atlanta, GA: US Department of Health and Human Services; 2021. https://millionhearts.hhs.gov/data-reports/hypertension-prevalence.html. Accessed October 20, 2022.
6. Khatib R, Schwalm JD, Yusuf S, et al. Patient and healthcare provider barriers to hypertension awareness, treatment and follow up: a systematic review and meta-analysis of qualitative and quantitative studies. *PLOS ONE.* 2014;9(1):e84238. https://doi.org/10.1371/journal.pone.0084238.
7. Ogedegbe G. Barriers to optimal hypertension control. *J Clin Hypertens (Greenwich).* 2008;10(8):644–646. https://doi.org/10.1111/j.1751-7176.2008.08329.x.
8. Carey RM, Muntner P, Bosworth HB, Whelton PK. Prevention and control of hypertension: JACC health promotion series. *J Am Coll Cardiol.* 2018;72(11):1278–1293. https://doi.org/10.1016/j.jacc.2018.07.008.
9. The guide to community preventive services. About the community Preventive Services Task Force. 2022 Updated https://www.thecommunityguide.org/task-force/about-community-preventive-services-task-force. Accessed August 28, 2022.
10. Proia KK, Thota AB, Njie GJ, et al. Team-based care and improved blood pressure control: a community guide systematic review. *Am J Prev Med.* 2014;47(1):86–99. https://doi.org/10.1016/j.amepre.2014.03.004.
11. Jacob V, Chattopadhyay SK, Thota AB, et al. Economics of team-based care in controlling blood pressure: a community guide systematic review. *Am J Prev Med.* 2015;49(5):772–783. https://doi.org/10.1016/j.amepre.2015.04.003.
12. Chattopadhyay SK, Jacob V, Hopkins DP, et al. Community guide methods for systematic reviews of economic evidence. *Am J Prev Med.* 2023;64(4):569–578. https://doi.org/10.1016/j.amepre.2022.10.015.
13. The Guide to Community Preventive Services. Heart Disease and Stroke Prevention: Team-based Care to Improve Blood Pressure Control. 2021. Updated https://www.thecommunityguide.org/findings/heart-disease-stroke-prevention-team-based-care-improve-blood-pressure-control. Accessed August 28, 2022.
14. The Guide to Community Preventive Services. Team-based Care Economic Analytic Framework. 2021. Updated https://www.thecommunityguide.org/sites/default/files/assets/AF-HDSP-Team-Based-Care-econ-p.pdf. Accessed August 28, 2022.
15. Eichler HG, Kong SX, Gerth WC, Mavros P, Jönsson B. Use of cost-effectiveness analysis in health-care resource allocation decision-making: how are cost-effectiveness thresholds expected to emerge? *Value Health.* 2004;7(5):518–528. https://doi.org/10.1111/j.1524-4733.2004.75003.x.
16. World Health Organization. Macroeconomics and Health: Investing in Health for Economic Development: Executive Summary/Report of the Commission on Macroeconomics and Health. Geneva, Switzerland: WHO; 2001. https://apps.who.int/iris/handle/10665/42463. Accessed August 28, 2022.
17. U.S. Bureau of Labor Statistics. Databases, tables & calculators by subject: CPI for all urban consumers (CPI-U). https://data.bls.gov/timeseries/CUUR0000SA0?output_view=pct_1mth. Accessed August 28, 2022.
18. The World Bank. Purchasing power parities. PPP conversion factor, private consumption (LCU per international $). https://data.worldbank.org/indicator/PA.NUS.PRVT.PP. Accessed August 28, 2022.
19. The World Bank. World Bank country and lending groups. https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups. Accessed August 28, 2022.
20. Adair R, Wholey DR, Christianson J, White KM, Britt H, Lee S. Improving chronic disease care by adding laypersons to the primary care team: a parallel randomized trial. *Ann Intern Med.* 2013;159(3):176–184. https://doi.org/10.7326/0003-4819-159-3-201308060-00007.
21. Allen JK, Dennison Himmelfarb CRD, Szanton SL, Frick KD. Cost-effectiveness of nurse practitioner/community health worker care to

reduce cardiovascular health disparities. *J Cardiovasc Nurs.* 2014;29(4):308−314. https://doi.org/10.1097/JCN.0b013e3182945243.

22. Augustovski F, Chaparro M, Palacios A, et al. Cost-effectiveness of a comprehensive approach for hypertension control in low-income settings in argentina: trial-based analysis of the hypertension control program in Argentina. *Value Health.* 2018;21(12):1357−1364. https://doi.org/10.1016/j.jval.2018.06.003.

23. Barton GR, Goodall M, Bower P, Woolf S, Capewell S, Gabbay MB. Increasing heart-health lifestyles in deprived communities: economic evaluation of lay health trainers. *J Eval Clin Pract.* 2012;18(4):835−840. https://doi.org/10.1111/j.1365-2753.2011.01686.x.

24. Billups SJ, Moore LR, Olson KL, Magid DJ. Cost-effectiveness evaluation of a home blood pressure monitoring program. *Am J Manag Care.* 2014;20(9):e380−e387.

25. Chan CW, Siu SC, Wong CK, Lee VW. A pharmacist care program: positive impact on cardiac risk in patients with type 2 diabetes. *J Cardiovasc Pharmacol Ther.* 2012;17(1):57−64. https://doi.org/10.1177/1074248410396216.

26. Chung JS, Lee KK, Tomlinson B, Lee VW. Clinical and economic impact of clinical pharmacy service on hyperlipidemic management in Hong Kong. *J Cardiovasc Pharmacol Ther.* 2011;16(1):43−52. https://doi.org/10.1177/1074248410380207.

27. Dehmer SP, Baker-Goering MM, Maciosek MV, et al. Modeled health and economic impact of team-based care for hypertension. *Am J Prev Med.* 2016;50(suppl 1):S34−S44 5. https://doi.org/10.1016/j.amepre.2016.01.027.

28. Dehmer SP, Maciosek MV, Trower NK, et al. Economic evaluation of the home blood pressure telemonitoring and pharmacist case management to control hypertension (hyperlink) trial. *J Am Coll Clin Pharm.* 2018;1(1):21−30. https://doi.org/10.1002/jac5.1001.

29. Dixon P, Hollinghurst S, Edwards L, et al. Cost-effectiveness of telehealth for patients with raised cardiovascular disease risk: evidence from the Healthlines randomised controlled trial. *BMJ Open.* 2016;6(8):e012352. http://doi.org/10.1136/bmjopen-2016-012352.

30. Fishman PA, Cook AJ, Anderson ML, et al. Improving BP control through electronic communications: an economic evaluation. *Am J Manag Care.* 2013;19(9):709−716.

31. Goetzel RZ, Kowlessar NM, Henke R, Benevent R, Tabrizi M, Colombi AM. Six-year cost trends at PPG Industries paralleling the introduction of health promotion programs directed at cardiovascular disease prevention. *J Occup Environ Med.* 2013;55(5):483−489. https://doi.org/10.1097/JOM.0b013e31828dc8ab.

32. Halladay JR, Tillman J, Hinderliter A, et al. Practice level costs of office-based hypertension performance improvement: the Heart Healthy Lenoir study. *J Healthc Manag.* 2017;62(2):136−150. https://doi.org/10.1097/JHM-D-17-00010.

33. He J, Irazola V, Mills KT, et al. Effect of a community health worker−led multicomponent intervention on blood pressure control in low-income patients in Argentina: a randomized clinical trial. *JAMA.* 2017;318(11):1016−1025. https://doi.org/10.1001/jama.2017.11358.

34. Henke RM, Goetzel RZ, McHugh J, Isaac F. Recent experience in health promotion at Johnson & Johnson: lower health spending, strong return on investment. *Health Aff (Millwood).* 2011;30(3):490−499. https://doi.org/10.1377/hlthaff.2010.0806.

35. Hollenbeak CS, Weiner MG, Turner BJ. Cost-effectiveness of a peer and practice staff support intervention. *Am J Manag Care.* 2014;20(3):253−260.

36. Hong JC, Padula WV, Hollin IL, et al. Care Management to Reduce Disparities and Control Hypertension in Primary Care: a Cost-effectiveness Analysis. *Med Care.* 2018 Feb;56(2):179−185. https://doi.org/10.1097/MLR.0000000000000852.

37. Houle SK, Chuck AW, McAlister FA, Tsuyuki RT. Effect of a pharmacist-managed hypertension program on health system costs: an evaluation of the Study of Cardiovascular Risk Intervention by Pharmacists-Hypertension (SCRIP-HTN). *Pharmacotherapy.* 2012;32(6):527−537. https://doi.org/10.1002/j.1875-9114.2012.01097.x.

38. Iles RA, Eley DS, Hegney DG, et al. Revenue effects of practice nurse-led care for chronic diseases. *Aust Health Rev.* 2014;38(4):363−369. https://doi.org/10.1071/AH13171.

39. Isetts BJ, Brummel AR, De Oliveira DR, Moen DW. Managing drug-related morbidity and mortality in the patient-centered medical home. *Med Care.* 2012;50(11):997−1001. https://doi.org/10.1097/MLR.0b013e31826ecf9a.

40. Katon W, Russo J, Lin EH, et al. Cost-effectiveness of a multicondition collaborative care intervention: a randomized controlled trial. *Arch Gen Psychiatry.* 2012;69(5):506−514. https://doi.org/10.1001/archgenpsychiatry.2011.1548.

41. Kulchaitanaroaj P, Brooks JM, Chaiyakunapruk N, Goedken AM, Chrischilles EA, Carter BL. Cost-utility analysis of physician−pharmacist collaborative intervention for treating hypertension compared with usual care. *J Hypertens.* 2017;35(1):178−187. https://doi.org/10.1097/HJH.0000000000001126.

42. Kulchaitanaroaj P, Carter BL, Goedken AM, Chrischilles EA, Brooks JM. Instrumental variable methods to assess quality of care the marginal effects of process-of-care on blood pressure change and treatment costs. *Res Social Adm Pharm.* 2015;11(2):e69−e83. https://doi.org/10.1016/j.sapharm.2014.07.007.

43. Monahan M, Jowett S, Nickless A, et al. Cost-effectiveness of telemonitoring and self-monitoring of blood pressure for antihypertensive titration in primary care (TASMINH4). *Hypertension.* 2019;73(6):1231−1239. https://doi.org/10.1161/HYPERTENSIONAHA.118.12415.

44. Overwyk KJ, Dehmer SP, Roy K, et al. Modeling the health and budgetary impacts of a team-based hypertension care intervention that includes pharmacists. *Med Care.* 2019;57(11):882−889. https://doi.org/10.1097/MLR.0000000000001213.

45. Panattoni L, Dillon E, Hurlimann L, Durbin M, Tai-Seale M. Cost estimates for designing and implementing a novel team care model for chronically ill patients. *J Ambul Care Manage.* 2018;41(1):58−70. https://doi.org/10.1097/JAC.0000000000000209.

46. Polgreen LA, Han J, Carter BL, et al. Cost-effectiveness of a physician-pharmacist collaboration intervention to improve blood pressure control. *Hypertension.* 2015;66(6):1145−1151. https://doi.org/10.1161/HYPERTENSIONAHA.115.06023.

47. Prezio EA, Pagán JA, Shuval K, Culica D. The Community Diabetes Education (CoDE) program: cost-effectiveness and health outcomes. *Am J Prev Med.* 2014;47(6):771−779. https://doi.org/10.1016/j.amepre.2014.08.016.

48. Reiss-Brennan B, Brunisholz KD, Dredge C, et al. Association of integrated team-based care with health care quality, utilization, and cost. *JAMA.* 2016;316(8):826−834. https://doi.org/10.1001/jama.2016.11232.

49. Shireman TI, Svarstad BL. Cost-effectiveness of Wisconsin TEAM model for improving adherence and hypertension control in black patients. *J Am Pharm Assoc (2003).* 2016;56(4):389−396. https://doi.org/10.1016/j.japh.2016.03.002.

50. Siaw MYL, Ko Y, Malone DC, et al. Impact of pharmacist-involved collaborative care on the clinical, humanistic and cost outcomes of high-risk patients with type 2 diabetes (Impact): a randomized controlled trial. *J Clin Pharm Ther.* 2017;42(4):475−482. https://doi.org/10.1111/jcpt.12536.

51. Simpson SH, Lier DA, Majumdar SR, et al. Cost-effectiveness analysis of adding pharmacists to primary care teams to reduce cardiovascular risk in patients with type 2 diabetes: results from a randomized controlled trial. *Diabet Med.* 2015;32(7):899−906. https://doi.org/10.1111/dme.12692.

52. Stoddart A, Hanley J, Wild S, et al. Telemonitoring-based service redesign for the management of uncontrolled hypertension (HITS): cost and cost-effectiveness analysis of a randomised controlled trial. *BMJ Open.* 2013;3(5). http://doi.org/10.1136/bmjopen-2013-002681.

53. Twiner MJ, Marinica AL, Kuper K, et al. Screening and treatment for subclinical hypertensive heart disease in emergency department

patients with uncontrolled blood pressure: A cost-effectiveness analysis. *Acad Emerg Med.* 2017;24(2):168−176. https://doi.org/10.1111/acem.13122.

54. Wagner TH, Willard-Grace R, Chen E, Bodenheimer T, Thom DH. Costs for a health coaching intervention for chronic care management. *Am J Manag Care.* 2016;22(4):e141−e146.

55. Almadfaa RO, Wigle PR, Hincapie AL, Guo JJ. The utilization, expenditure, and price of angiotensin-converting enzyme inhibitors and angiotensin receptor blockers in the US Medicaid programs: trends over a 31 year period. *Int J Cardiol.* 2023;370:412−418. https://doi.org/10.1016/j.ijcard.2022.10.152.

56. Desai RJ, Sarpatwari A, Dejene S, et al. Comparative effectiveness of generic and brand-name medication use: A database study of US health insurance claims. *PLOS Med.* 2019;16(3):e1002763. https://doi.org/10.1371/journal.pmed.1002763.

57. An J, Derington CG, Luong T, et al. Fixed-dose combination medications for treating hypertension: a review of effectiveness, safety, and challenges. *Curr Hypertens Rep.* 2020;22(11):95. https://doi.org/10.1007/s11906-020-01109-2.

58. Derington CG, Cohen JB, Bress AP. Restoring the upward trend in blood pressure control rates in the United States: a focus on fixed-dose combinations. *J Hum Hypertens.* 2020;34(9):617−623. https://doi.org/10.1038/s41371-020-0340-6.

59. Kotchen TA. Developing hypertension guidelines: an evolving process. *Am J Hypertens.* 2014;27(6):765−772. https://doi.org/10.1093/ajh/hpt298.

60. Saklayen MG, Deshpande NV. Timeline of history of hypertension treatment. *Front Cardiovasc Med.* 2016;3:3. https://doi.org/10.3389/fcvm.2016.00003.

61. OECD. *Health at a Glance 2019: OECD Indicators*, Paris: OECD Publishing. https://doi.org/10.1787/4dd50c09-en.