Comparative Effectiveness of Implementation Strategies for Blood Pressure Control in Hypertensive Patients: A Systematic Review and Meta-analysis

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Abstract

Background—The prevalence of hypertension is high and increasing worldwide while the proportion of controlled hypertension is low.

Purpose—To assess the comparative effectiveness of 8 implementation strategies for blood pressure (BP) control in adults with hypertension.

Data Sources—Systematic searches of MEDLINE and Embase from inception to September 2017 with no language restriction supplemented with manual reference searches.

Study Selection—Randomized controlled trials lasting at least 6 months comparing implementation strategies versus usual care on BP reduction in adults with hypertension.

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Data Extraction—Two investigators independently extracted trial data. Trials were grouped by implementation strategy, and BP reduction effects were compared using multivariate-adjusted generalized estimating equations. A modified Cochrane Risk of Bias tool was used for trial quality assessment.

Data Synthesis—A total of 121 comparisons from 100 articles with 55,920 hypertensive patients were included. Multilevel, multicomponent strategies, such as team-based care with medication titration by non-physician [−7.1 mmHg (95% CI: −8.9, −5.2)], team-based care with medication titration by physician [−6.2 mmHg (−8.1, −4.2)], and multilevel strategies without team-based care [−5.0 mmHg (−8.0, −2.0)] were most effective for systolic BP reduction. Patient-level strategies also resulted in significant systolic BP reductions of −3.9 mmHg (−5.4, −2.3) for health coaching and −2.7 mmHg (−3.6, −1.7) for home BP monitoring. Similar trends were observed for diastolic BP reduction. Provider training was tested in few trials and resulted in non-significant BP reduction.

Limitations—Sparse data from low- and middle-income countries, few trials of some implementation strategies, and possible publication bias.

Conclusions—Multilevel, multicomponent strategies, followed by patient-level strategies, are most effective for BP control in patients with hypertension and ought to be used to improve hypertension control.

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Introduction

Hypertension is a major public health challenge due to its high prevalence and associated cardiovascular disease and premature death (1,2). Pharmaceutical treatment and lifestyle modifications have been shown to reduce blood pressure (BP) and cardiovascular disease risk in randomized clinical trials (3,4). Despite these proven-effective BP interventions, only 13.8% of adults with hypertension and 37.1% of patients with treated hypertension had their BP controlled worldwide in 2010 (1). Barriers to hypertension control at health care system, health care provider, and patient levels have been identified (5). For example, limited health care resources, lack of performance standards, and limited reimbursement for health coaching are major barriers to BP control at the health care system level; lack of adherence to clinical guidelines is a major barrier to BP control at the health care provider level; and lack of adherence to prescribed medications and lifestyle modifications are major barriers at the patient level (5).

Implementation strategies to overcome the barriers to BP control, such as home BP monitoring, health coaching, provider training, and team-based care have been tested in randomized trials (6,7). Most trials, however, have relatively small sample sizes and limited statistical power to provide a reliable estimate of intervention effects. Two previous reviews of implementation strategies for BP reduction included studies published up to 2003 and 2008, respectively (6,7). They showed that compared to usual care, a number of implementation strategies, including team change and home BP monitoring, significantly improved BP control (6,7). However, the effects of various implementation strategies on BP control have not been directly compared in these meta-analyses. In addition, many

implementation strategy trials have been published in the recent years. In the current meta-analysis, we aim to assess the comparative effectiveness of various implementation strategies on BP reduction in patients with hypertension by direct comparison. This information could be used by government and non-government organizations to select the most effective implementation strategies for hypertension control in communities.

Methods

We developed and followed a protocol for all steps of the review and meta-analysis (Supplement 1).

Data Sources and Searches

MEDLINE and Embase were searched from inception to September 11, 2017 with search terms "hypertension" or "blood pressure" and an extensive list of terms related to provider education, team-based care, patient education, provider feedback and guideline adherence, and home BP monitoring (Appendix Table 1 and Appendix Table 2) (6–9). The search was restricted to clinical trials in human adults and had no language restrictions. Additional studies were identified by manual review of references cited in reviews, meta-analyses, and original articles. An extensive search of clinicaltrials.gov was also conducted to find additional trials and to assess publication bias by identifying completed trials without published results.

Study Selection

A study was eligible for inclusion if 1) it was a randomized controlled trial; 2) study participants were adults with hypertension defined as average systolic BP   140 mmHg, average diastolic BP   90 mmHg, and/or use of antihypertensive medication; 3) a main trial outcome was the net change in systolic BP or diastolic BP; 4) the trial intervention targets barriers to hypertension control at one or more of the patient, provider, and healthcare system levels; 5) the control group received usual care or minimal education ; 6) the trial duration was at least six months; 7) variance of BP changes (or data to calculate it) was reported; and, 8) if a trial was cluster-randomized, clustering must be accounted for in the analysis. No language restrictions were made. Two investigators independently screened all abstracts to determine initial eligibility. They further reviewed full texts for potentially eligible studies. Disagreements were resolved by consensus.

Data Extraction and Quality Assessment

Two investigators independently extracted data from each included trial using a standardized data collection form. Extracted data included study design, participant characteristics, intervention descriptions and study results. Data from the two investigators were compared, and discrepancies were resolved by consensus. For trials reporting results at more than one time point, the report closest to the end of the intervention was selected.

Trials were divided into eight implementation strategy categories based on intervention descriptions (Table 1). Categories were created based on prior literature and availability of trials meeting our inclusion criteria (6,7). Two categories address patient-level barriers to BP

control only: (1) health coaching and (2) home BP monitoring; three categories target provider-level barriers only: (3) provider training, (4) audit and feedback, and (5) electronic decision support systems; and three categories are multilevel strategies: (6) multilevel strategies without team-based care, (7) team-based care with physicians titrating medications, and (8) team-based care with non-physician providers titrating medications.

Health coaching strategies could be delivered in-person or by telephone at multiple individual or group sessions over the intervention period. The strategies are patient-centered with a component of behavioral self-monitoring. A health coach (case manager, nurse, medical assistant or community health worker) and patients worked together using self-discovery or active learning processes to improve medication adherence and lifestyle modification (10). Provider-level strategies aim to improve BP management performance of healthcare professionals primarily responsible for patient hypertensive care. Multilevel implementation strategies are aimed at overcoming barriers to hypertension control at two or more levels of patients, providers, health care systems, and communities. Team-based care is characterized by inter-professional collaboration, a patient-centered approach, and an integrated care process (12). In this meta-analysis, team-based care implementation strategies involve task-shifting or task-sharing from primary care physicians in hypertension patient care to nurses, pharmacists, or community health workers. Team-based care is divided into two categories depending on whether or not the non-physician provider can titrate medications. The multilevel strategies without team-based care category includes any intervention that targets more than one level of barriers to BP control, but does not include team-based care, such as patient health coaching combined with provider training. Multicomponent strategies are those that combine more than one approach regardless of barrier level.

Trials were included if their control groups were either usual care or minimal education. Usual care is defined as hypertension management conducted by patients' normal care providers with no trial intervention. Minimal education includes the provision of educational materials or a brief educational session to either patients or providers.

The Cochrane Risk of Bias tool was modified to make it applicable to cluster trials in implementation research and used for assessing trial quality (13). In this meta-analysis, we have focused on the following domains for study quality assessment: random sequence generation, objective outcome assessment (blinding of BP observers or use of automatic BP cuffs), incomplete outcome data, and selective outcome reporting. Participant recruitment bias was also considered for cluster-randomized trials. Funding sources for all trials were also recorded. Risk of bias assessments were done at the trial level.

Data Synthesis and Analysis

For each trial the net change in mean BP and associated standard error was calculated from available data and defined as the difference (intervention minus control) in the changes of mean values (follow-up minus baseline). If BP was measured at multiple time points during follow-up, the measurements taken closest to the end of the intervention were used. In addition, the changes in mean BP and associated standard errors in each randomized group were calculated separately for comparing effects among implementation strategies.

Random effects models using the Sidik-Jonkman residual heterogeneity estimator with the Knapp-Hartung small sample adjustment were used to calculate pooled mean differences within implementation categories using inverse variance weighting (14–16). In some trials, multiple intervention arms were compared to the same reference group. In these cases, robust variance estimation was used to account for non-independent estimates (17). Heterogeneity was evaluated using the Q test and quantified with the I^2 index and 95% confidence interval calculated using the test-based method (18). Publication bias was assessed using Begg's rank correlation test and Egger's weighted linear regression test for implementation strategies with at least ten studies due to low statistical power with small sample sizes. When possible publication bias was observed, the trim-and-fill method was used to estimate the number of missing studies not published, augment the data to make the funnel plot more symmetrical, and calculate a summary estimate based on the augmented data (19).

Generalized estimating equations (with an exchangeable correlation matrix between estimates within a study) were used to compare BP reductions associated with each implementation strategy after important covariate adjustment and for pairwise comparisons between implementation strategies. Indicator variables were used for each implementation strategy category with the common control group as the reference. Weights for these models were exported from a random effects meta-analysis including all changes in mean BP and associated standard errors from all treatment groups. As such, these weights take into account within and between trial variance. Trial was treated as a cluster to maintain randomized comparisons, and trial-level baseline characteristics were adjusted: logit-transformed proportion male, centered mean age, centered mean systolic BP, centered trial duration, and whether the control group was usual care or minimal education. A sensitivity analysis was conducted including only trials where all participants had uncontrolled hypertension at baseline.

Analyses were conducted using packages metafor, robumeta, and forestplot in R version 3.3.2 (R Project for Statistical Computing) and PROC GENMOD in SAS version 9.4 (SAS Institute, Cary, NC).

Role of the Funding Source

Results

After excluding duplicates, our search strategy identified 6,697 references, of which 958 underwent full text review (Figure 1). In total, 100 articles reporting 121 comparisons with 55,920 participants were included (Appendix Table 3). The median of the study-specific mean ages was 60 years (range: 33–77), and the median of the study-specific mean baseline systolic and diastolic BP were 148 mmHg (range: 124–190) and 86 mmHg (range: 70–105). Trials ranged in length from 6 months to 5 years (median: 6 months). The number of

comparisons per implementation category ranged from 38 for health coaching to 2 for audit and feedback (Table 2). Among all trials, none were identified at high risk of bias for random sequence generation, three for objective outcome assessment, 13 for incomplete outcome data, two for selective reporting, and one for recruitment bias (Appendix Tables 4 and 5). Of the 88 studies reporting funding information, 17% reported receiving full or partial funding from pharmaceutical firms. The rest were funded from federal, state, and local governments, foundations, and universities.

Effects of implementation strategies

All five patient-level and multilevel implementation strategies were associated with significant reductions in systolic BP (Appendix Figure 1). Health coaching and home BP monitoring significantly reduced systolic BP by −4.3 mmHg (95% CI: −5.9, −2.6; p<0.001) and −2.2 mmHg (95% CI: −3.5, −1.0; p=0.001), respectively. The multilevel strategies without team-based care reduced systolic BP by −3.9 mmHg (95% CI: −6.5, −1.3; p=0.003). Team-based care with physicians and non-physician providers titrating medications had the largest pooled mean systolic BP reductions of −5.7 mmHg (95% CI: −7.9, −3.6; p<0.001) and −6.6 mmHg (95% CI: −9.0, −4.2; p<0.001), respectively. Strategies targeting provider-level barriers to BP control did not significantly reduce BP compared to the control group. Some evidence of publication bias was observed for health coaching (Egger p=0.27; Begg p=0.051) and team-based care with physicians titrating medications (Egger p=0.146; Begg p=0.020). However, trim-and-fill analysis showed that publication bias did not account of the observed associations for health coaching [−4.3 mmHg (95% CI: −6.1, −2.6; p<0.001)] or for team-based care with physicians titrating medications [−4.2 mmHg (95% CI: −6.5, −1.8; p<0.001)]. In addition, a search of clinicaltrials.gov identified 191 trials potentially eligible for inclusion in these analyses. Of these, only three (one home BP monitoring and two health coaching) met our inclusion criteria, completed primary outcome collection more than two years ago, and had not reported results. This suggests reported results are not attributed to publication bias.

Similar results were observed for diastolic BP (Appendix Figure 2). Health coaching [−1.9 mmHg (95% CI −2.8, −1.0; p<0.001)], home BP monitoring [−1.5 mmHg (−2.0, −1.0; p<0.001)], team-based care with titration by a physician [−2.5 mmHg (−3.9, −1.1; p=0.002)], and team-based care with medication titration by a non-physician provider [−3.5 mmHg (−4.6, −2.5; p<0.001)] were all associated with a significant reduction in diastolic BP compared to the control group. Multilevel strategies without team-based care [−2.7 mmHg (−6.0, 0.6; p=0.114)] was not significantly associated with significant diastolic BP reduction. Provider training, audit and feedback, and electronic decision support systems were also not associated with a significant decline in diastolic BP.

Comparative effectiveness of implementation strategies

After adjustment for important covariates and all implementation strategies simultaneously using generalized estimating equations, the three multilevel strategies were the most effective for systolic BP reduction (Figure 2). Team-based care with medication titration by a non-physician [−7.1 mmHg (95% CI: −8.9, −5.2; p<0.001)] had the greatest reduction in systolic BP, followed by team-based care with medication titration by a physician [−6.2

mmHg (95% CI: −8.1, −4.2; p<0.001)], and multilevel strategies without team-based care [−5.0 mmHg (95% CI: −8.0, −2.0; p=0.001)]. The patient-level strategies of health coaching [−3.9 mmHg (95% CI: −5.4, −2.3; p<0.001)] and home BP monitoring [−2.7 mmHg (95% CI: −3.6, −1.7; p<0.001)] were also significantly associated with reductions in systolic BP. After multivariate adjustment, electronic decision support systems [−3.7 mmHg (95% CI: −5.2, −2.2; p<0.001)] was associated with a significant systolic BP reduction, but provider training, and audit and feedback were not. Likewise, team-based care with medication titration by a non-physician [−3.1 mmHg (95% CI: −4.1, −2.2; p<0.001)] had the greatest reduction in diastolic BP, followed by multilevel strategies without team-based care [−2.9 mmHg (95% CI: −5.4, −0.4; p=0.025)] and team-based care with medication titration by a physician [−2.7 mmHg (95% CI: −3.8, −1.5; p<0.001)]. The patient-level strategies of health coaching [−2.1 mmHg (95% CI: −2.9, −1.3; p<0.001)] and home BP monitoring [−1.5 mmHg (95% CI: −2.3, −0.8; p<0.001)] were also significantly associated with reductions in diastolic BP. Electronic decision support systems [−1.5 mmHg (95% CI: −1.9, −1.1; p<0.001)] was the only provider-level strategy associated with a significant reduction in diastolic BP. Similar results were observed for patient-level and multilevel interventions when analyses included only trials where all participants had uncontrolled BP at baseline (Appendix Figure 3). There were insufficient studies meeting this criteria to estimate summary effects for audit and feedback and provider training.

Pairwise comparison of implementation strategies

Table 3 provides a pairwise comparison of the intervention strategies ordered by effect sizes of systolic BP reduction and adjusted for covariates. Team-based care with titration by a non-physician resulted in significantly greater systolic BP reductions than any of the patient-level and provider-level strategies ranging from −3.22 to −6.29 mmHg for systolic BP and significantly greater diastolic BP reductions than home BP monitoring and all the provider-level strategies ranging from −1.60 to −2.52 mmHg for diastolic BP. Team-based care with titration by a physician also resulted in a significantly greater reduction in systolic BP compared to all patient-level and provider-level strategies except health coaching.

Conclusions

Our findings indicate that implementation strategies targeting multiple-level or patient-level barriers are effective for BP reduction. Specifically, team-based care with and without a non-physician team member titrating medications and multilevel strategies without team-based care were the most effective implementation strategies for hypertension control. In addition, patient health coaching and home BP monitoring were also effective.

These findings have important public health implications. Despite strong evidence that antihypertensive medications and lifestyle modifications reduce BP and subsequent cardiovascular disease morbidity and mortality, hypertension control rates are low worldwide (5). The US Institute of Medicine and the National Heart Lung and Blood Institute have both called for research focusing on integrating evidence-based strategies into routine health care for hypertension control (20,21). Our findings provide evidence that multilevel, multicomponent implementation strategies are most useful and should be

recommended in clinical practice and public health policy for hypertension control in communities.

Two previous meta-analyses of intervention strategies for BP reduction reviewed studies published up to 2003 and 2008 and showed that a number of implementation strategies, including team-based care and home BP monitoring, compared to the control group improved hypertension control (6,7). Since 2008 through September 2017 (MEDLINE search), meta-analyses for some individual implementation strategies have been published (8,22–25), but none that included all implementation strategies for BP control. Our study expanded on the previous meta-analyses by including many trials published since 2008. Moreover, our meta-analysis is the first study to directly compare the effectiveness of various implementation strategies on BP control after adjusting for key trial and participant characteristics. Generalized estimating equations using studies as clusters allowed for comparisons of intervention strategies while still preserving individual study randomization.

Team-based care strategies, where hypertension management responsibilities are shared among team members (i.e., nurses, pharmacists, medical assistants, or community health workers) in addition to primary care physicians, were found to be most effective for BP control in our analyses. Santschi and colleagues reported that compared with usual care, pharmacist-led interventions showed greater reductions in systolic (7.6 mmHg, 95% CI: 6.3 to 9.0) and diastolic BP (3.9 mmHg, 95% CI: 2.8 to 5.1) in a meta-analysis of randomized controlled trials (22). In addition, Clark and colleagues reported that compared with usual care, nurse-led interventions with a nurse prescribing medications showed greater reductions in systolic (8.9 mmHg, 95% CI: 5.3 to 12.5) and diastolic BP (4.0 mmHg, 95% CI: 2.7 to 5.3) in a meta-analysis of four trials (23). Team-based care is particularly effective because it frees physicians' time to focus on urgent and complex cases, while allowing for patient-centered care that is tailored, frequent, and collaborative (28). Taken together, our findings and those from previous research provide strong evidence that team-based care is an effective approach for BP control among hypertensive patients (24,27,28).

Among the included trials reporting positive findings, pharmacist-led team-based care often includes provider training, health coaching, and/or home BP monitoring, in addition to task-sharing by pharmacists (29–34). Likewise, nurse-led team-based care usually includes health coaching and/or home BP monitoring (35,36). Community health worker-led team-based strategies typically include health coaching, home BP monitoring, and provider training (37). Multilevel implementation strategies without team-base care commonly consist of health coaching, home BP monitoring, and/or provider training (38,39). In some multilevel intervention trials, pharmacists conducted medication titration, health coaching, and/or home BP monitoring independent of the primary care team (40). Clearly, multilevel, multicomponent strategies, combining team-based care, health coaching, home BP monitoring, and provider training, have been proven to be the most effective strategy for BP control among patients with hypertension.

Our findings also showed that health coaching and home BP monitoring alone resulted in significant BP reduction among hypertensive patients. Health coaching is effective for behavioral change, including lifestyle modification and antihypertensive medication

adherence (41). Therefore, in settings where multilevel strategies are not feasible due to limited resources, health coaching, especially when combined with home BP monitoring, might be an effective alternative for BP control. Future studies testing whether health coaching plus home BP monitoring provides a cost-effective approach could help to inform BP control strategies in populations with health disparities.

A few trials tested strategies targeting only physician-level barriers to hypertension control (i.e., provider training, audit and feedback, and electronic decision support systems), and only electronic decision support systems was significantly association with BP reduction after multivariate adjustment while contributing only four trials to the analysis. Although provider-level strategies had limited effect on their own, these intervention strategies were commonly a part of multilevel, multicomponent strategies shown to be effective. For example, Veterans Affairs medical centers and Kaiser Permanente have seen improvements in BP control among their patients after adopting multilevel strategies that included audit and feedback and electronic decision support systems (42–44). Due to the limited number of trials available in this category, the positive findings for electronic decision support systems after adjustment, and the effective use of these interventions as part of multicomponent interventions, future clinical trials are needed to test additional physician-targeted implementation strategies, such as physician-patient communication which could improve patient engagement and adherence to hypertension treatment (45,46).

Our analyses have several limitations. First, despite the inclusion of a large number of trials in this meta-analysis, some implementation strategies did not have sufficient numbers of studies. For example, provider training, audit and feedback, electronic decision support systems, and multilevel strategies without team-based care all had less than 10 comparisons. Second, very few multilevel intervention trials addressed system-level barriers (i.e., lack of performance standards, leadership commitment, and reimbursement of physician-to-patient health coaching). These factors could have a substantial impact on BP control among patients with hypertension and should be evaluated in future studies. Third, few clinical trials tested the effect of implementation strategies for free or low cost medications or financial incentives on BP control. They did not meet our inclusion criteria and were not included in this meta-analysis. Fourth, there were insufficient studies conducted in subgroups of interest, such as patients with diabetes or chronic kidney disease, to estimate associations within these groups. Finally, only 20% of included trials were from low- and middle-income countries where uncontrolled hypertension is a serious public health problem. However, many studies included were conducted in low-income, ethnic minority, and other populations with health disparities in the US and other high-income countries. Furthermore, sixteen studies funded by the Global Alliance for Chronic Disease will help to partially fill this knowledge gap (37,47).

In order to translate these findings into routine clinical practice through scale-up and dissemination at the healthcare system level, additional research is needed on cost-effectiveness and sustainability of implementation strategies for BP control (20, 26). While some trials included in this meta-analysis conducted cost-effectiveness analyses (31, 33, 34, 37, 38, 48–52), there were not enough data for a systematic review. In addition, there were no long-term follow-up studies after trial completion to assess intervention sustainability.

In conclusion, multilevel, multicomponent implementation strategies with and without team-based care are most effective for BP control among patients with hypertension. In addition, health coaching and home BP monitoring targeting barriers at the patient level are also effective. These strategies should be disseminated and scaled up in clinical practices and public health programs to improve hypertension control in communities.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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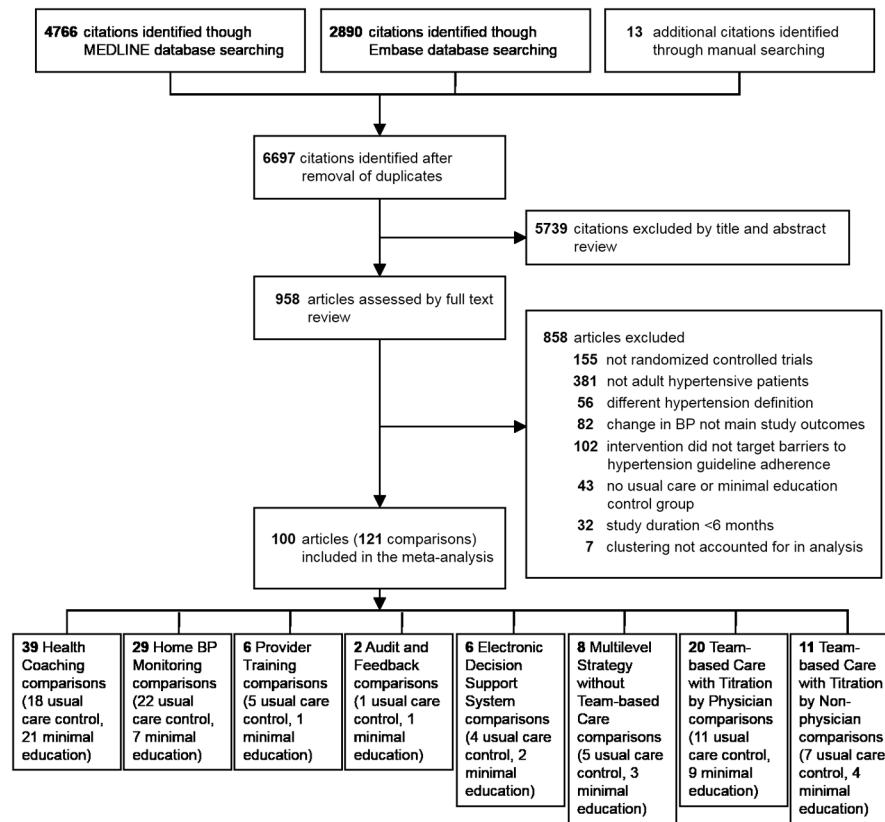
Figure 1.
Flowchart of Study Selection

Systolic Blood Pressure

Implementation Strategies		Net Change in BP (95% CI), mmHg	Number of Studies
Team-based Care with Titration by Non-physician		-7.1 (-8.9, -5.2)	10
Team-based Care with Titration by Physician		-6.2 (-8.1, -4.2)	19
Multilevel Strategy without Team-based Care		-5.0 (-8.0, -2.0)	8
Health Coaching		-3.9 (-5.4, -2.3)	38
Electronic Decision Support Systems		-3.7 (-5.2, -2.2)	4
Home Blood Pressure Monitoring		-2.7 (-3.6, -1.7)	26
Provider Training		-1.4 (-3.6, 0.7)	5
Audit and Feedback		-0.8 (-2.1, 0.5)	2

```
         -15       0        15
        Net Change in Blood Pressure, mmHg
```

Diastolic Blood Pressure

Implementation Strategies		Net Change in BP (95% CI), mmHg	Number of Studies
Team-based Care with Titration by Non-physician		-3.1 (-4.1, -2.2)	10
Multilevel Strategy without Team-based Care		-2.9 (-5.4, -0.4)	8
Team-based Care with Titration by Physician		-2.7 (-3.8, -1.5)	16
Health Coaching		-2.1 (-2.9, -1.3)	37
Home Blood Pressure Monitoring		-1.5 (-2.3, -0.8)	27
Electronic Decision Support Systems		-1.5 (-1.9, -1.1)	2
Provider Training		-1.0 (-2.2, 0.1)	5
Audit and Feedback		-0.6 (-1.3, 0.1)	2

```
         -15       0        15
        Net Change in Blood Pressure, mmHg
```

Figure 2. Adjusted Mean Net Reduction in Blood Pressure Associated with Implementation Strategies

Mean net reduction in systolic blood pressure (upper panel) and diastolic blood pressure (lower panel). Mean net reductions estimated using generalized estimating equations and adjusted for sex, age, baseline systolic (or diastolic) blood pressure, trial duration, type of control group, and all other intervention strategies. Boxes weighted by sample size.

Table 1

Implementation Strategy Category Descriptions

Implementation Strategy Category	Description
Patient-level	
Health Coaching (10)	Multiple sessions for patient-centered health education and motivation delivered with the goal of facilitating lifestyle modification and/or medication adherence.
Home Blood Pressure Monitoring	Self-monitoring of patient blood pressure and recording of measurements either manually or by automatic electronic transmission; blood pressure readings provided to providers.
Provider-level	
Provider Training	Education or training targeting providers on hypertension management, including guideline adherence (treatment goals, lifestyle intervention, and medication titrations), and/or patient communication
Audit and Feedback (11)	Repeated, periodic summaries of patient outcomes given to providers, such as blood pressure values, so they can evaluate and improve patient care; could also include provider training
Electronic Decision Support System (11)	Computerized alerts, reminders, or order sets intended to aid providers in point of care decision making; could also include provider training
Multilevel	
Multilevel Strategy without Team-based Care	Interventions that target barriers to hypertension control at multiple levels but do not include team-based care, such as a combination of provider training and patient health coaching
Team-based Care with Physicians Titrating Medications (12)	Collaborative provision of care for hypertension by at least two providers, including a primary care physician who titrates medications, working collaboratively with patients to accomplish shared treatment goals.
Team-based Care with Non-Physician Providers Titrating Medications (12)	Collaborative provision of care for hypertension by at least two providers, including a non-physician team member who titrates medications, working collaboratively with patients to accomplish shared treatment goals.

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Table 2

Summary Characteristics of Trials by Implementation Strategy

Implementation Strategy	No. of Studies[*]	No. of Participants	Mean Age Range, years	Sex Range, % of Male	Mean Baseline SBP Range, mmHg	Mean Baseline DBP Range, mmHg	Duration	Study Design	BP Measurement Methods		Control Categories
									No. of Measurements	Type of Device	
Patient-level											
Health Coaching	39	10,656	33–74	0–100	124–181	70–105	6 months – 2 years	97% parallel RCTs (30% cluster-randomized); 3% Factorial RCTs	one visit, 2–6 measurements (n=19); two visits, 2 measurements each (n=1); unknown (n=18)	automated (n=15), standard mercury (n=8), automated or standard mercury (n=1), random zero (n=2), unknown (n=12)	46% usual care, 54% minimal education
Home Blood Pressure Monitoring	29	7,966	47–77	21–92	126–170	72–104	6 months – 2 years	100% parallel RCTs (8% cluster-randomized)	one visit, 2–6 measurements (n=15); two visits, 3 measurements each (n=1); nine visits, 1 measurement each (n=1); daytime ambulatory (n=1); routine clinic measurements (n=1); unknown (n=7)	automated (n=13), standard mercury (n=2), random zero (n=1), aneroid (n=1), ambulatory (n=1), device used in clinic (n=3), unknown (n=5)	76% usual care, 24% minimal education
Provider-level											
Provider Training	6	17,642	53–67	35–47	127–153	74–96	6 months – 2 years	100% parallel RCTs (100% cluster-randomized)	one visit, 3 measurements (n=2); 24-hour ambulatory (n=1); routine clinic measurements (n=1); unknown (n=2)	automated (n=2), ambulatory (n=1), device used in clinic (n=1), unknown (n=2)	83% usual care, 17% minimal education
Audit and Feedback	2	2,121	61–62	54–64	133–146	73–89	6 months – 2 years	100% parallel RCTs (100% cluster-randomized)	two visits, 2 measurements each (n=1); unknown (n=1)	automated (n=1), unknown (n=1)	50% usual care, 50% minimal education
Electronic Decision Support System	6	8,229	54–69	22–97	136–158	75–89	6 – 18 months	100% parallel RCTs (100%	one visit, 2 measurements (n=1); routine clinic	automated (n=3), device used in clinic	67% usual care, 33% minimal education

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Implementation Strategy	No. of Studies[*]	No. of Participants	Mean Age Range, years	Sex Range, % of Male	Mean Baseline SBP Range, mmHg	Mean Baseline DBP Range, mmHg	Duration	Study Design	BP Measurement Methods		Control Categories
									No. of Measurements	Type of Device	
								cluster-randomized)	measurements (n=4); unknown (n=1)	(n=2), unknown (n=1)	
Multilevel											
Multilevel Strategy without Team-based Care	8	3,436	53–67	30–100	133–169	73–95	6 months – 2 years	100% parallel RCTs (75% cluster-randomized)	one visit, 2–3 measurements (n=5); two visits, 2 measurements each (n=1); unknown (n=2)	automated (n=6), standard mercury (n=1), unknown (n=1)	63% usual care, 37% minimal education
Team-based Care with Physicians Titrating Medications	20	6,680	47–68	21–99	127–162	76–93	6 – 18 months	100% parallel RCTs (30% cluster-randomized)	one visit, 2–4 measurements (n=8); two visits, 3 measurements each (n=1); 24-hour ambulatory (n=1); routine clinic measurements (n=2); unknown (n=5)	automated (n=7), standard mercury (n=5), random zero (n=1), aneroid (n=1), device used in clinic (n=2), unknown (n=1)	55% usual care, 45% minimal education
Team-based Care with Non-Physician Providers Titrating Medications	11	3,417	41–68	31–100	136–174	76–99	6 months – 5 years	100% parallel RCTs (18% cluster-randomized)	one visit, 1 measurement (n=1); one visit, 2–3 measurements (n=8); two visits, 3 measurements each (n=1); routine clinic measurements (n=1)	automated (n=6), standard mercury (n=2), random zero (n=1), device used in clinic (n=1), unknown (n=1)	64% usual care, 36% minimal education

[*] A total of 121 comparisons from 100 publications and 55,920 participants are included.

Sixteen publications contribute more than one comparison because they have multiple treatment arms.

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Table 3

Comparison of Systolic and Diastolic Blood Pressure Reduction among Implementation Strategies

Adjusted Difference (95% Confidence Interval) in Mean Diastolic Blood Pressure Reduction, mm Hg	Adjusted Difference (95% Confidence Interval) in Mean Systolic Blood Pressure Reduction, mm Hg						
Team-based care with titration by non-physician	−0.88 (−3.58, 1.80)	−2.05 (−5.53, 1.43)	−3.22 (−5.72, −0.72)*	−3.35 (−5.75, −0.96)†	−4.41 (−6.50, −2.32)‡	−5.63 (−8.57, −2.69)‡	−6.29 (−8.52, −4.05)‡
−0.48 (−1.95, 0.99)	**Team-based care with titration by physician**	−1.16 (−4.73, 2.41)	−2.34 (−4.86, 0.18)	−2.47 (−4.42, −0.52)*	−3.52 (−5.56, −1.49)‡	−4.74 (−7.66, −1.83)†	−5.40 (−7.71, −3.09)‡
−0.29 (−2.84, 2.26)	0.19 (−2.55, 2.93)	**Multilevel strategy without team-based care**	−1.17 (−4.47, 2.13)	−1.30 (−4.60, 1.99)	−2.36 (−5.48, 0.76)	−3.58 (−8.02, 0.86)	−4.24 (−6.26, −2.22)‡
−1.08 (−2.29, 0.14)	−0.60 (−2.03, 0.84)	−0.79 (−3.26, 1.69)	**Health coaching**	−0.13 (−2.28, 2.02)	−1.19 (−3.00, 0.63)	−2.41 (−4.71, −0.11)*	−3.06 (−5.04, −1.09)†
−1.68 (−2.64, −0.72)‡	−1.19 (−2.09, −0.30)†	−1.39 (−3.85, 1.08)	−0.60 (−1.48, 0.28)	**Electronic decision support system**	−1.06 (−2.78, 0.66)	−2.28 (−4.93, 0.38)	−2.93 (−4.81, −1.06)†
−1.60 (−2.71, −0.48)†	−1.12 (−2.50, 0.27)	−1.31 (−3.87, 1.25)	−0.52 (−1.62, 0.58)	0.08 (−0.76, 0.91)	**Home blood pressure monitoring**	−1.22 (−3.61, 1.18)	−1.88 (−3.48, −0.28)*
−2.12 (−3.57, −0.68)†	−1.64 (−3.28, 0.00)	−1.83 (−4.61, 0.95)	−1.04 (−2.35, 0.27)	−0.44 (−1.65, 0.77)	−0.52 (−1.90, 0.85)	**Provider training**	−0.66 (−3.60, 2.28)
−2.52 (−3.54, −1.51)‡	−2.04 (−3.40, −0.67)†	−2.23 (−4.21, −0.25)†	−1.44 (−2.36, −0.53)†	−0.84 (−1.57, −0.12)*	−0.92 (−1.92, 0.07)	−0.40 (−1.73, 0.93)	**Audit and feedback**

Adjusted for sex, age, baseline systolic blood pressure (or diastolic blood pressure), trial duration, and type of control group. Strategies are ordered by rankings of net reduction in mean systolic blood pressure. Blood pressure reduction differences are in the cell in common between the row-defining and column-defining implementation strategy. For the mean difference in systolic blood pressure, the column strategy blood pressure reduction minus the row strategy blood pressure reduction. For the mean difference in diastolic blood pressure, the difference is the column strategy minus the row strategy. For example, the differences in mean systolic and diastolic blood pressure reduction between team-based care with titration by a non-physician and health coaching are −3.22 (95% CI: −5.72 to −0.72) and −1.08 (−2.29 to 0.14), respectively.

*
P <0.05;

†
P <0.01; and

‡
P <0.001