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Primary care clinician education interventions for improving blood pressure control for people prescribed antihypertensive treatment: a systematic review and meta-analysis

Sulaiman Althuwaikh,[1] Kingshuk Pal,[2] Bader Alterkait,[3] Nour Mandani,[3] Sophie V Eastwood [4]

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[1]Internal Medicine Department, Al-Amiri Hospital, Kuwait City, Kuwait
[2]Prince of Wales Group Practice, London, UK
[3]Internal Medicine Department, Sheikh Jaber Al-Ahmad Al-Sabah Hospital, Kuwait City, Kuwait
[4]Unit for Lifelong Health and Ageing at UCL, University College London, London, UK

Correspondence to
Dr Sophie V Eastwood;
sophie.eastwood@ucl.ac.uk

ABSTRACT

Introduction Half of people treated for hypertension are not controlled to target; clinician education may improve effective antihypertensive use.

Objectives To systematically review and synthesise evidence from 2010 to 2024 on primary care clinician education interventions for improving blood pressure (BP) control in people on antihypertensive treatment.

Design Systematic literature review.

Data sources MEDLINE, Embase and CINAHL were searched in January 2024.

Setting Primary care.

Participants Primary care clinicians and patients with hypertension.

Interventions Randomised controlled trials from 2010 to 2024 of clinician education interventions, based in primary care and reporting BP change pre-intervention versus post-intervention, were included. The primary outcome was post-intervention difference in systolic BP (SBP). The secondary outcome was change in the proportion of participants with BP controlled to target.

Data extraction and synthesis Abstracts were screened by four researchers; then, data were extracted from selected studies using a pre-designed proforma. Bias was assessed using the Cochrane collaboration's risk of bias tool. Results were synthesised using meta-analysis and intervention content was narratively analysed.

Results A total of 73 full-text articles were screened for eligibility, of which 5 met the inclusion criteria. Meta-analysis showed no evidence of benefit (SBP reduction of −1.24 mm Hg (95% CI −3.95 to 1.47)). Of note, all bar one study reported inconclusive results. Further analysis of included studies suggested that benefit may be more likely for interventions of longer duration, involving more frequent follow-up and targeting higher risk patients.

Conclusions Current available evidence indicates clinician education interventions are unlikely to improve BP control in primary care when used in isolation.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ Inadequately treated hypertension is a major global public health problem; this review provides a rigorous, up-to-date synthesis of available evidence on clinician educational interventions for improving hypertension management.
⇒ The five included studies were geographically diverse, but methodologically comparable.
⇒ Combined study effects were assessed by meta-analysis, which showed no evidence of benefit.
⇒ Accordingly, we would not recommend clinician education interventions as a sole strategy for improving hypertension management.

INTRODUCTION

Hypertension (or high blood pressure (BP)) affects 25% of the world's population[1] and is the most potent modifiable risk factor for cardiovascular disease[2] (CVD), itself still the leading cause of death globally.[3] Antihypertensive medication reduces CVD risk by up to 30%[4] and is widely available in most high-income and middle-income settings.[5] Yet only ≈50% of those prescribed antihypertensive treatment have adequate BP control.[6]

Clinician education interventions present a cost-effective, convenient and scalable strategy for addressing drivers of inadequate BP control such as therapeutic inertia[7] (ie, absence of treatment up-titration when poor BP control is detected) and poor communication with patients around adherence and lifestyle. Recent examples of such interventions have included didactic teaching to clinicians[8–11] (particularly focusing on treatment algorithms[8] or patient follow-up strategies,[10] case-based training,[8 12] provision of written materials for the consultation room[10] and promotion of shared decision-making with the patient.[12]

Nevertheless, a synthesis of contemporaneous evidence is lacking regarding the effectiveness of clinician education in lowering BP. A 2010 systematic review of healthcare

professional educational interventions to improve BP in people with hypertension reported no evidence of benefit (mean systolic BP (SBP) difference: −0.4 mm Hg, 95% CI −1.1 to +0.2 mm Hg).[13] However, many included studies were over 25 years old, and several important changes to guidelines and practice have taken place in the interim[14]—most notably the increased granularity of treatment thresholds and targets according to clinical factors such as chronic kidney disease and age. Furthermore, previous interventions are unlikely to have accounted for the modern focus on communication and shared decision-making with patients.[12] These considerations may mean that hypertension management is now more likely to benefit from enhanced clinician education, and thus newer interventions may offer benefits over interventions assessed in the previous review.

Therefore, this systematic review aims to identify, analyse and synthesise the effects of primary care clinician education interventions for improving BP control in people on antihypertensive treatment since 2010.

METHODS

The objectives, inclusion criteria and methods for conducting the systematic review were pre-specified by three authors (SA, KP and SVE) and documented in a protocol prior to commencement of the study (online supplemental file 1). The Preferred Reporting Items for Systematic reviews and Meta-Analyses guidelines were followed for writing the report[15] (online supplemental file 2).

Search strategy

We searched MEDLINE, EMBASE and CINAHL for relevant articles. The search strategy used medical subject headings (MeSH) and keywords for hypertension and antihypertensives and combined them with MeSH and keywords for medical education and primary care healthcare professionals (online supplemental table 1). The Cochrane collaboration's recommended filter for randomised controlled trials (RCTs) was applied.[16] The search was restricted to English language studies published between January 2010 and January 2024. Studies prior to 2010 were excluded because they were less likely to correspond to contemporary medical practice and guidelines on antihypertensive use[17] and may have been previously reported in the review by Glyn *et al*.[13] Reference lists of included studies were also inspected to identify any further studies meeting the eligibility criteria.

Study inclusion criteria

Searches were restricted to RCTs, including cluster and/or factorial RCTs. According to the PICO (*P*opulation, *I*ntervention, *C*ontrol, *O*utcomes) framework, inclusion criteria were (see online supplemental table 2 for further details) as follows:

Population

Healthcare professionals working in primary care settings—of note, trials targeting solely patients were excluded.

Intervention

Consisted of education or training to improve antihypertensive medication prescribing for primary or primary and secondary prevention in adult, non-pregnant patients. This could include didactic teaching, interactive case-based training, instruction on the use of consultation aids (such as paper copies of guidelines) and communication skills teaching (eg, on shared decision-making) where it was relevant to antihypertensive treatment. Trials targeting exclusively secondary prevention and those conducted in secondary care settings were excluded due to the reduced scalability and potential lack of cost-effectiveness of the findings, given hypertension is predominantly managed in primary care. For the same reason, trials involving extra personnel, pay for performance or telemonitoring methods were also excluded. We did not include interventions involving communication skills training only, as these were deemed non-specific to the study question.

Comparator

Usual care, that is, routine primary care management of hypertension with antihypertensives. Where factorial trials were included, the comparison was between the intervention arm of interest (ie, clinician education) and the usual care arm, that is, only data pertinent to the review question were included.

Outcome

The primary outcome was post-intervention difference in SBP, or post-intervention SBP where change was not reported. The secondary outcome was change in the proportion of participants with BP controlled to target.

There were no restrictions on the intervention duration or length of follow-up, and where studies reported outcomes at multiple time points, we included the outcome reported at the final time point.

Study selection

After removal of duplicate citations, two authors screened the title and abstract of each study identified by the literature search (all were screened by SA, with subsections doubly screened by SVE, NM and BA, approximately a third each). Studies featuring clinician education-based antihypertensive prescribing interventions (which did not obviously flout any of the above eligibility criteria) were selected, with any disagreements being resolved by consensus with a separate author (KP or SVE for the abstracts she did not screen). Full-text articles were then accessed and re-screened according to the eligibility criteria to determine the final included studies.

Data extraction

We developed a data collection tool, which was initially tested on three studies, then refined. We extracted data

on the characteristics of the study population including baseline SBP, country, number of primary care practices and/or clinicians, details of the intervention, follow-up duration and outcomes in the intervention and control groups.

Statistical analysis

We combined all included studies using meta-analysis since all interventions were methodologically comparable, presented sufficient information to enable comparison and described the comparable effects (SBP change post-intervention). We used Revman software (Cochrane Collaboration) to create forest plots. Data from cluster RCTs that already accounted for clustering in their reported effects were included as given in the source articles. For those that did not account for clustering, we addressed their likely unit-of-analysis error by deriving their 'effective sample size' using methods suggested by the Cochrane Collaboration.[18] In brief, this involved calculating the 'design effect' (design effect=1+ [mean cluster size −1] × intra-class correlation coefficient), then dividing in turn the control and intervention sample sizes by the design effect to produce new 'effective sample sizes', that is, accounting for clustering. These were then entered, rather than the sample sizes given in the source article, into the meta-analysis.

The outcome variable was the change in mean SBP (ie, post-intervention SBP − pre-intervention SBP). For the studies that provided SEs or 95% CI[8–10], we obtained SDs using the formulae: SE = (upper CI − lower CI) / 3.92 and SD=SE× √N. We used a random effects model and assessed heterogeneity using the I^2 statistic. Effective interventions were designated by a p value ≤0.05 for intervention versus control post-intervention differences in SBP reductions.

We performed a sensitivity analysis to explore heterogeneity of effects in the meta-analysis, excluding the two studies with mandated enhanced patient follow-up.[8 10]

Assessment of trial quality

The Cochrane Collaboration's Risk of Bias Tool (for cluster RCTs where relevant) was used to assess potential bias for each study.[16] Three authors (SA, NM and BA) assessed articles for risk of bias by assigning a high or low risk of bias to each domain and combined the results graphically to aid visualisation of findings. The number of studies was too few to assess publication bias using a funnel plot, but of note, all but one of the studies had null or negative results.

Patient and public involvement

There was no patient or public involvement in this research.

RESULTS

Citation searches of MEDLINE, EMBASE and CINAHL yielded 1964 citations, as of January 2024; 852 of these were identified as duplicates. Of these, after abstract screening, 73 studies were selected for full-text review, 5 of which were subsequently included in the final analysis[8–12] (figure 1). The most common reasons for exclusion were absence of an educational focus to the intervention (17/68, 25%) or a lack of randomisation (11/68, 16%). No additional studies were identified from searching the reference lists of the included articles, though for Jafar *et al*[8] (which was primarily a cost-effectiveness study), further details were sought from an earlier paper.[19]

Study populations

Data for 3976 patients across five studies were assessed, with 1832 (46%) from a single study[10] (table 1). Patients were recruited from between 2[9] and 37[12] different primary care facilities. All studies bar one[9] were cluster RCTs, two randomised by primary care practice;[11 12] one by community[8] and one by region.[10] The targeted healthcare professional was primary care physicians (henceforth referred to as 'GPs' (general practitioners)) for four studies,[9–12] and unspecified in one.[8] For clusters where the intervention was offered, uptake by GPs was voluntary and reported by two studies (as 66%[8] and 90%[10]). Three studies explicitly stated that patients were blinded to physician allocation,[8 9 12] though procedures for patient recruitment were unclear in all but one study,[10] in which physicians were instructed to recruit the first seven patients meeting the inclusion criteria that they saw. Most control groups received only usual care, with one exception where they received a 90 min training lecture.[10] One study recruited hypertensive patients from the community (including antihypertensive-naïve people),[8] but all other patient populations were recruited via primary care facilities (two including people with and without prior antihypertensive use,[11 12] and two restricted to established antihypertensive users.[9 10] Study populations were either being treated for a mixture of primary and secondary prevention,[10 12] or this was unspecified.[8 9 11] Studies were conducted in France,[10] Germany,[11 12] the USA[9] and Pakistan.[8] Three studies had a female (>60% female patients)[8 9] and one a male[10] preponderance. Mean patient age ranged from 54[9] to 65[12] years, and baseline SBP from 131 mm Hg[12] (ambulatory BP) to 153 mm Hg[8] (clinic BP). Maximum follow-up times were between 5[11] and 24[8 10] months, with a median of 18 months. The educational interventions were delivered either on one single day[8 10 12] or as several sessions within a short (unspecified) time period.[9 11] Two studies also followed patients up at four to six monthly interim visits.[8 10] Studies were published between 2011 and 2016. Three studies reported post-intervention changes in mean SBP as the primary outcome[8 9 12] and two reported proportions with controlled BP as the primary outcome[10 11] (with change in SBP as the secondary outcome). These were recorded by GPs in

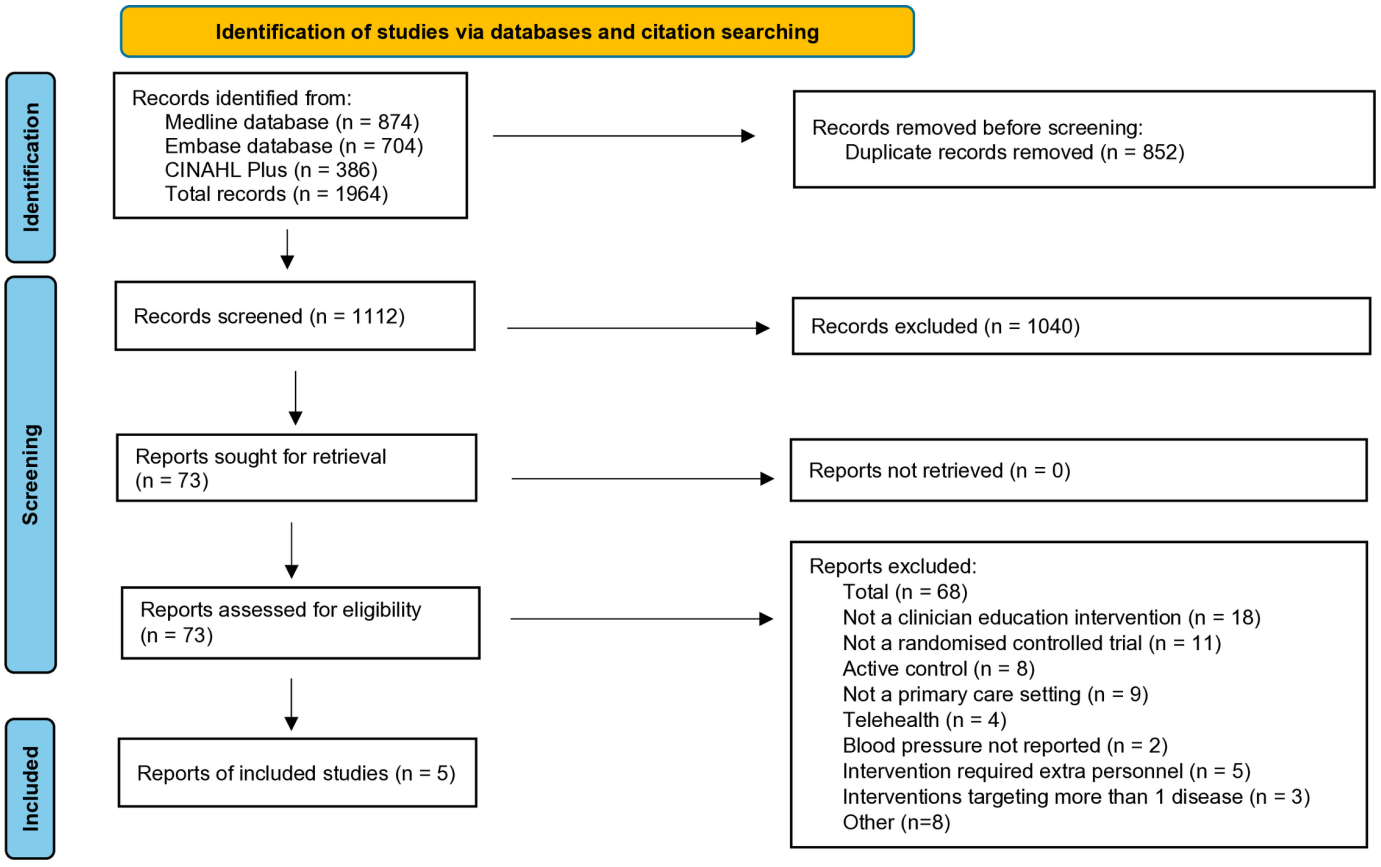

Figure 1 Preferred Reporting Items for Systematic reviews and Meta-Analyses flowchart of study selection process.

two studies,[9 10] study staff in another[8] and unspecified people in the remaining studies.[11 12]

Risk of bias assessment

Of the five studies included, risk of bias was deemed low for two studies,[10 12] high for one[9] and uncertain for the remaining two studies[8 11] as they did not include enough information to allow full assessment (figure 2). Two studies described attempts to blind clinicians (either by not informing GPs of the study endpoints and offering a lecture to the usual care group[10] or by using 'waiting list controls'[11]), but the difficulty in doing so was acknowledged by all studies.[8–12] The one positive trial was considered to be at low risk of bias.[10]

Outcomes

All selected studies reported change in SBP. Of the four cluster RCTs, three provided BP change estimates accounting for clustering.[8 11 12] For the study that did not provide this information, we calculated a 'design effect' of 4.93 from a mean cluster size of 80 (1832 participants/23 clusters) and an assumed intra-class correlation

Table 1 Characteristics of studies of clinician education interventions for improving antihypertensive prescribing

Study	Country	Practices or clinicians, N	Patients, N	N (%) female)	Mean (SD) age, years	Baseline mean (SD) SBP, mm Hg
Johnson *et al*[9] (2011)	USA	2 primary care practices	I: 203 C: 57	I: 124 (61) C: 34 (60)	I: 54 (14.1) C: 61 (13.5)	I: 146.0 (14.2) C: 143.0 (16.7)
Jafar *et al*[8] (2011)	Pakistan	127 general practitioners (249 for all arms of study)	I: 335 C: 326	I: 197 (59) C: 208 (64)	I: 55.3 (11.5) C: 53.3 (11.5)	I: 153.3 (24.6)* C: 153.3 (24.6)*
Pouchain *et al*[10] (2013)	France	257 general practitioners	I: 905 C: 927	I: 330 (36) C: 338 (36)	I: 62.1 (7.9) C: 62.4 (7.7)	I: 145.9 (15.3) C: 138.7 (13.5)
Tinsel *et al*[12] (2013)	Germany	36 general practices	I: 552 C: 568	I: 294 (53) C: 314 (55)	I: 63.8 (12.1) C: 65.0 (12.4)	I: 133.2 (13.6) C: 130.8 (12.6)
Weltermann *et al*[11] (2016)	Germany	22 practices	I: 63 C: 40	I: 29 (46) C: 16 (40)	I: 58.7 (13.5) C: 63.4 (13.4)	I: 147.2 (11.8) C: 146.1 (12.7)

*Extracted from 2009 paper.[19]
C, control; I, intervention; SBP, systolic blood pressure.

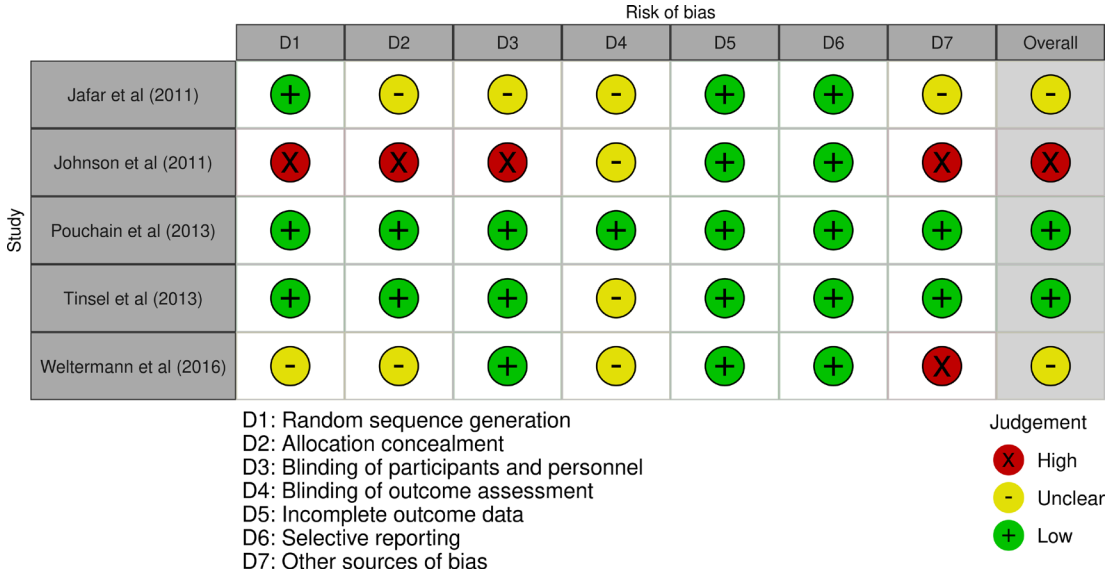

Figure 2 Risk of bias assessment.

coefficient of 0.05.[20] Both intervention (n=905) and control (n=927) group sizes were then divided by the 'design effect' to produce 'effective sample sizes' of 183 and 188, respectively.

Meta-analysis of the five included studies[8–12] showed no conclusive evidence for a beneficial effect for primary care clinician educational interventions, with post-intervention reductions in SBP being on average −1.24 mm Hg (95% CI −3.95 to 1.47) non-significantly greater in intervention than in control groups (figure 3, see online supplemental figure 1 for meta-analysis without adjustment for clustering, which shows similar results to the main analysis). Only one study reported a significant post-intervention SBP reduction[10] (table 2, figure 3). Three studies adjusted for baseline covariates[8–10] (including variously: age, sex, cluster, baseline SBP, arm of BP measurement, diabetes, smoking and alcohol, see table 2) and two did not.[11 12] There was substantial heterogeneity of effects, with an I^2 of 73% (figure 3). I^2 was greatly reduced to 25% when the two studies involving enhanced follow-up[8 10] were removed (figure 4). Two other studies reported non-significantly better BP lowering for intervention versus control groups (of 1.50 mm Hg (95% CI −10.90 to 7.90)[9] and −2.60 mm Hg (−7.27 to 2.07)[11]), while another two reported non-significantly better BP lowering in the control than in intervention groups (of 0.20 mm Hg (−2.46 to 2.86)[8] and 1.24 mm Hg (−0.11 to 2.59)[12]).

Four studies also examined the likelihood of achieving target BP post-intervention[8–10 12] (table 2). Results were similar in direction to the mean BP changes described above, with studies reporting intervention versus control proportions achieving BP targets at the end of the study of 18.6% versus 2.7%,[9] 13.8% versus 3.7%,[10] and 12.5% versus 14.8%[12] and an OR for control of 1.0 (95% CI 0.8 to 1.4).[8]

DISCUSSION

This meta-analysis of randomised controlled trials of primary care clinician education to improve antihypertensive prescribing showed no evidence of benefit. Therefore, based on this evidence, we would not recommend the routine use of clinician education as a sole intervention for improving primary care management of hypertension. Our results suggest that benefit may be more likely for longer duration interventions, involving more frequent follow-up and targeting higher risk patients.

Our findings broadly correspond with those of a 2010 Cochrane review of 10 healthcare professional educational interventions to improve BP in people with hypertension, which reported no evidence of benefit (mean SBP difference −0.4 mm Hg, 95% CI −1.1 to +0.2 mm Hg, ORs for BP control from 0.8 to

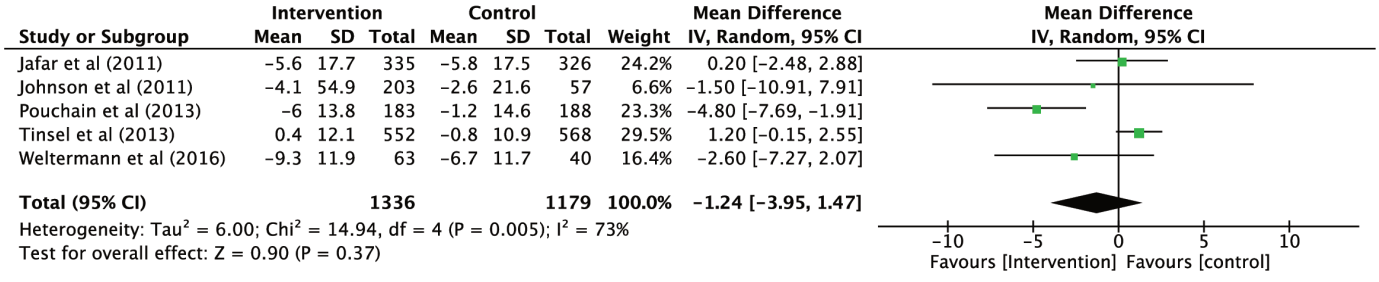

Figure 3 Meta-analysis of mean systolic blood pressure change following clinician education interventions.

Table 2 Interventions, primary outcome and results for each trial

Study	Intervention	Duration, months	Change in mean systolic BP, mm Hg	Change in % achieving target BP
Johnson *et al*[9] (2011)	I: hypertension specialists gave a series of 90 min didactic and interactive lectures to primary care physicians, every 2 months over 2.5 years. Topics included cardiovascular health disparities, pathophysiology of primary and secondary hypertension, pharmacologic and non-pharmacologic hypertension management, managing comorbidities and research methods. (Also had patient education only and patient+physician education arms.) C: usual care.	6	I: −4.1 (95% CI −11.7 to 3.4) C: −2.6 (95% CI −8.2 to 3.0) Adjusted for age, sex, arm of measurement, diabetes, smoking, alcohol	I: +18.6% C: +2.7%
Jafar *et al*[8] (2011)	I: GP education: 1-day training session focusing on treatment algorithms, including teaching on pharmacologic and non-pharmacologic interventions, using an interactive, case-based curriculum. C: usual care.*	24	I: −5.6 (95% CI −7.5 to −3.7) C: −5.8 (95% CI −7.7 to −3.9) Adjusted for clustering, age, sex, baseline SBP	OR (95% CI) for control: GP education versus intervention; 1.0 (0.8 to 1.4)
Pouchain *et al*[10] (2013)	I: GPs had a 1-day training session about therapeutic targets and strategies to achieve them as recommended by French guidelines. Also, they were given a six-page leaflet on the above and asked to keep it on their desks. They were asked to schedule a BP follow-up appointment every 6 months to patient not reaching targets, to discuss lifestyle and adherence, and given feedback on the patient's biological data at 12 months. C: usual care. Attended a 90 min meeting to learn about inclusion/exclusion criteria for the trial. They were not told about the study aims or the intervention.	24	I: −6.00 (SE: 0.46) C: −1.24 (SE: 0.48) Similar results when adjusted for baseline SBPs	I: +13.8% C: +3.7%
Tinsel *et al*[12] (2013)	I: GP education 6-hour shared decision-making training programme, including information on hypertension and options for lowering cardiovascular risk, communication with patients, steps of shared decision-making, motivational interviewing and case vignettes for role play. C: usual care.	18 months	I: 0.43 (SD: 12.08) C: −0.81 (SD: 10.92)	I: +12.5% C: +14.9%
Weltermann *et al*[11] (2016)	I: three education sessions for primary care physicians, combining evidence-based information and practice implementation strategies. Sessions were provided by four hypertension specialists. C: usual care.	5 months	I: −9.3 (SD: 11.9) C: −6.7 (SD: 11.7)	-

*Extracted from 2009 paper.[19]
BP, blood pressure; C, control; GPs, general practitioners; I, intervention; SBP, systolic blood pressure.

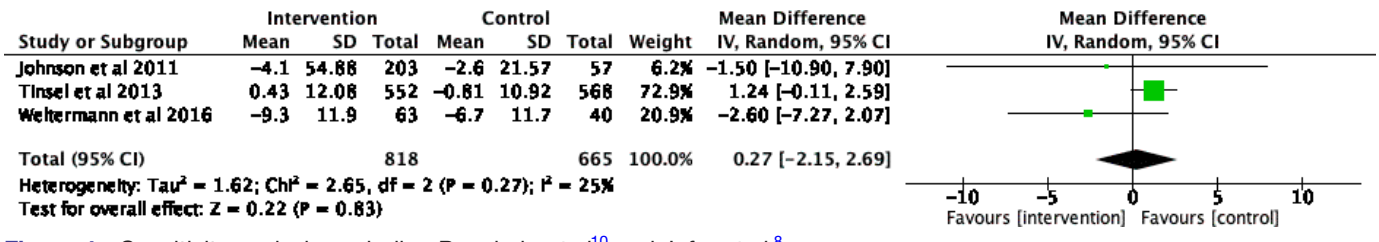

Figure 4 Sensitivity analysis excluding Pouchain *et al*[10] and Jafar *et al*.[8]

1.0).[13] However, unlike the 2010 review, our study suggested a non-significant tendency towards benefit. Differences may be explained by study vintage—encouraging algorithm use to combat therapeutic inertia was the cornerstone of most interventions in this review,[8–12] but five of the studies in the Cochrane review preceded 2000, when use of management guidelines was less widespread in many settings.[14] Additionally, most interventions in the Cochrane review consisted of computerised decision support or use of risk charts, with none featuring communication skills training; a vital pathway to promoting medication adherence, itself a key driver of successful interventions.[21]

Study characteristics associated with effectiveness

Several aspects of study design may have increased effectiveness. First, the duration of interventions may have contributed to success; the one successful intervention was one of the longest, at 2 years. Improvement of medication intensification rates is likely to have partly driven an intervention's effectiveness,[22] but many patients with hypertension will only be reviewed every 6–12 months[23] and treatment may only be intensified at every few visits.[24] Therefore, BP changes are more appropriately evaluated in the medium to long term. The two studies that non-significantly favoured the intervention had the shortest follow-up time (5 and 6 months, respectively). These were also the smallest studies; therefore, they may have been more likely to show a favourable effect if they had been longer and better powered. Second, the intensity of follow-up may have heightened the probability of success. Only two studies provided interim follow-up for participants: one via three times per year BP assessments[8] and one via six monthly follow-up appointments *and* yearly communication of BP parameters to clinicians[10]—the latter was the single successful intervention. More regular follow-up provides more opportunities for treatment intensification and lifestyle and adherence counselling; regular review has been shown to improve BP control across a variety of settings.[25 26] Third, increased antihypertensive use at the end of the study may have been key; the only study noting increased use was the sole effective one[10] (out of three reporting antihypertensive use[8 10 11]). Fourth, effectiveness appeared more likely in populations with higher baseline BPs and levels of CVD risk. Three of the ineffective studies included newly diagnosed patients,[8 11 12] who are likely to have only marginally raised BPs.[11 12] This may have resulted in a 'ceiling effect', that is, reduced potential for marked BP lowering. Of note, a post hoc analysis of one, restricted to individuals with treatment-resistant hypertension, showed the intervention was effective.[11] The two studies selecting uncontrolled or 'high-risk' patients with existing hypertension were effective[10] (albeit one non-significantly[9]). Generally, the content of interventions was similar and featured teaching on hypertension and its management; however, the only successful study also provided a leaflet for GPs to keep on their desks, reiterating knowledge and treatment guidelines.[10]

Conversely, several study characteristics appeared unrelated to effectiveness, including the level of randomisation (community, region, practice), the length of training (three interventions provided a 1-day session,[8 10 12] one provided three sessions[11] and one a session every 2 months for 2.5 years[9]—this latter intervention was non-significantly beneficial), whether participating GPs were from university-affiliated teaching practices (both such studies described non-effective interventions[12]), setting (the only beneficial study was in a high-income country,[10] and the study from a low-income country[8] and one in an underserved community in a high-income country[9] were non-beneficial) and patient attrition rates (these were not given for the one successful intervention, but ranged from 8%[9] to 21%[11] for the other studies). In terms of intervention content, some studies allowed GPs to select teaching topics,[11] provided training on communication skills and motivational interviewing[8 11 12] or used case vignettes and role play to consolidate knowledge,[8 9 12] but these did not appear to be related to success.

Several other outcomes, though beyond the scope of this review, were described. Two studies commented on the high acceptability of interventions to GPs.[9 11] CVD outcomes were reported for one study, which were non-significantly higher in the control.[10] Four studies examined intermediate outcomes to attempt to elucidate mechanisms for intervention effectiveness: Jafar *et al* reported an increase in antihypertensive prescribing and adherence and lifestyle improvements in the intervention compared with the control groups,[8] and Pouchain *et al* (the single effective study) reported higher numbers of antihypertensives prescribed for the intervention group.[10] Two of the negative studies reported no effects of the intervention on antihypertensive adherence, patient knowledge and CVD risk scores,[12] or numbers of antihypertensives prescribed.[11] Importantly, two factorial studies which featured combined patient and clinician education arms described greater BP reductions in those arms versus clinician education only arm (ie, reductions of 12 mm Hg vs 6 mm Hg[8] and 12 mm Hg vs 4 mm Hg[9]). Furthermore, these studies both demonstrated significantly more effective BP lowering in the combined patient and clinician education than in control arms.[8 9] These findings suggest combinations of interventions may be more advantageous than sole ones.

Strengths and limitations

We provide rigorous up-to-date evidence on cost-effective, scalable interventions addressing a key public health issue. Further strengths include the focus on the outcome (change in SBP) most likely to exert clinical effect and a comprehensive risk of bias assessment. Interventions were similar in nature (albeit with differing populations and levels of implementation), enabling valid comparisons. The review included a study from a low-income setting[8] and one

aimed at an underserved population,[9] which may have improved generalisability. However, a key drawback of this review is the heterogeneity of results, rendering interpretation problematic, as much of the beneficial effect was driven by one large study. Therefore, we urge cautious interpretation of results. Additionally, selection bias may have detracted from the generalisability of the findings (as with all randomised controlled trials); GPs and patients willing to take part may be those who are more motivated to appropriately manage hypertension already. This was compounded by a lack of randomisation procedures at the GP or patient level in the included studies and could have biased the findings towards the null (via better BP lowering in the control arm than expected by chance). However, four out of five included studies reported cluster RCTs,[8 10–12] where randomisation was at the level of the cluster, but results were provided at the level of the patient—this could have led to a unit-of-analysis error. We tried to ameliorate this by using cluster-adjusted estimates. Moreover, this type of error tends to overestimate treatment effects;[27] therefore, it may be less of a concern for this meta-analysis, given the aggregated result was null. GP and patient recruitment and participation rates were poorly described in all but one study,[10] rendering it difficult to evaluate the impact of selection bias on the findings. Moreover, our aim was to evaluate interventions targeting primary care clinicians (including practice nurses, who provide much of the care for people with hypertension in the UK[28]), but all but one study focused on physicians (GPs); this may limit the applicability to UK practice. External validity could have been hampered further by the inclusion of two studies with a university-affiliated teaching practice population, though this did not seem to impact outcomes. Attrition, though rates in all included studies were commensurate with expected levels for similar interventions,[29] may have also affected outcomes, possibly biasing towards the null as patients lost to follow-up could have been those most likely to benefit from interventions.

Further research should investigate mechanisms of intervention action so that successful mechanisms can be amplified in future interventions, for example, by measuring therapeutic inertia before and after interventions. Interventions targeting nurse and/or pharmacist education should be evaluated, given these professionals manage the majority of hypertension in the UK.[28] Implications on workload should be carefully evaluated. Modes of intervention delivery, for example, remotely via video call, should be evaluated to potentially maximise cost-effectiveness and scalability. While we deliberately did not focus on digital interventions due to concerns about equitable uptake in low-income or deprived settings,[30] our findings may inform future digital interventions. If possible, efforts should be directed towards longer-term, sustainable initiatives, preferably coupled with patient education. Finally, CVD outcomes should be measured, after a suitable lag period, to establish preventative effectiveness as well as intermediate outcome (SBP) control.

In summary, hypertension is the key modifiable CVD risk factor and affects a quarter of the world's population,[1] yet is inadequately controlled by pharmacological treatment in at least a third of treated cases.[5] Thus, there is a major need to identify new models of care, particularly cost-effective ones, and this study provides important new evidence on this front. Education of primary care clinicians is a simple, acceptable and feasible[8–12] approach which could be rolled out at scale (eg, by remote delivery). Our findings do not support the routine use of current models of clinician education as sole interventions for suboptimal hypertension management, but suggest that more intensive, longer-term interventions may have a role in managing higher-risk patients.[10] The scalability of such interventions, in addition to the high prevalence of inadequately treated hypertension,[5] and the capacity for population-wide CVD amelioration afforded by better treatment[31 32] mean that even modest SBP reductions at population level present important implications for future care.

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terminology, drug names and drug dosages), and is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

ORCID iD

Sophie V Eastwood http://orcid.org/0000-0002-1883-8771

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