Thapa *et al. Conn Health Telemed* 2023;2:2000013
DOI: 10.20517/chatmed.2023.09

Connected Health And Telemedicine

Review

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Interventions of eHealth technologies integrated with non-physician health workers for improving management of hypertension: Systematic review and meta-analysis

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How to cite this article: Thapa R, Takele WW, Thrift A, Zengin A. Interventions of eHealth technologies integrated with non-physician health workers for improving management of hypertension: Systematic review and meta-analysis. *Conn Health Telemed* 2023;2:2000013. https://dx.doi.org/10.20517/chatmed.2023.09

Received: 14 Nov 2023 **First decision:** 4 Dec 2023 **Revised:** 20 Dec 2023 **Accepted:** 27 Dec 2023 **Published:** 29 Dec 2023

Academic Editors: Yuanting Zhang, Aletta Elisabeth Schutte **Copy Editor:** Yanbing Bai **Production Editor:** Yanbing Bai

Abstract

Hypertension is a major public health problem, accounting for 7.5 million deaths and 57 million disability-adjusted life years annually worldwide. The majority of hypertension-related deaths occur in low- and middle-income countries (LMICs). Despite the escalating prevalence of hypertension in many LMICs, only one-third of men and less than half of women with hypertension were aware of their hypertension status in Sub-Saharan Africa, and South Asia. The rapid proliferation of eHealth technologies presents an opportunity to improve the detection and management of hypertension. Many LMICs face a critical shortage of physicians, and their services often come at a considerable cost to the health system. Non-physician health workers could be a cost-effective alternative to improve the detection and management of hypertension, particularly in LMICs. In this systematic review, we aim to synthesize and evaluate the effectiveness of interventions that integrated eHealth technologies with non-physician health workers to reduce blood pressure. A diverse range of eHealth technologies, such as mobile-based applications, telemonitoring, short text messaging and electronic decision support systems, are being used by non-physician health workers for the management of hypertension. We found that eHealth technologies integrated with non-physician health workers reduced overall mean systolic blood pressure by -4.09 mmHg (95%CI: -5.87 to -2.32) compared to usual care. Similarly, such an integrated approach also reduced diastolic blood pressure by -1.25

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mmHg (-2.31 to -0.81) in the intervention group than usual care. Therefore, leveraging the use of cost-effective eHealth technologies to support task-sharing with non-physicians presents an effective strategy for enhancing blood pressure management, applicable to both high- and low-income countries.

Keywords: Hypertension, blood pressure, task-sharing, eHealth intervention, non-physician health workers intervention

INTRODUCTION

Hypertension is a major public health problem[1]. Annually, hypertension is estimated to cause 7.5 million deaths and 57 million disability-adjusted life years globally[2], with 90% of hypertension-related deaths occurring in low- and middle-income countries (LMICs)[3]. The prevalence of hypertension is increasing in LMICs that are experiencing rapid epidemiological and demographic transition[3], and is fuelled by low awareness, treatment and control of hypertension. Approximately 50%-60% of women and nearly 70% of men with hypertension in LMICs remain unaware of their condition, while control of hypertension remains as low as 13%[1].

Innovative approaches are required to sustain and scale interventions aimed at reducing blood pressure (BP), particularly as LMICs face a critical shortage of specialized workforce, mainly in the southeast Asian and African regions[4]. Non-physician health workers are recognized as a potential cost-effective alternative to physicians for providing primary care[5-7], and are increasingly being mobilized to deliver health education, lifestyle interventions and management of non-communicable diseases (NCDs)[8]. The proliferation of eHealth technologies, such as mobile health, web and internet-based messaging and telemedicine, provides opportunities to support non-physicians to improve the management of NCDs such as hypertension and diabetes. eHealth interventions have been widely applied across people living with NCDs, health care providers, health care managers and data services. In this systematic review, we aimed to systematically synthesize and evaluate the effectiveness of interventions integrating eHealth technologies to support non-physician interventions to reduce BP.

METHODS

Data sources and search strategy

This systematic review and meta-analysis adheres to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines[9]. We undertook a comprehensive search of three databases: Ovid MEDLINE, EMBASE, and EBSCO CINAHL. A manual search was performed on the reference lists of identified studies. The search was carried out between May 2023 and June 2023 and included articles from the database inception to June 2023. The initial search strategy was developed in MEDLINE based on a previous review of community health worker interventions[6] and task-sharing with non-physicians for blood pressure reduction[10] and refined to maximize the sensitivity and specificity for identifying relevant articles, and to identify a maximum number of relevant articles. The search strategy was further modified for use in other databases. Our broad search strategy included terms such as "community health workers", "nurses", "pharmacist", "dieticians", "non-physicians" and "eHealth", "mHealth", and "digital health" together with "hypertension" or "elevated blood pressure" [Supplementary Table 1].

Inclusion and exclusion criteria

We included randomized controlled trials of interventions delivered by non-physician health workers through eHealth technologies. For our review, all the healthcare professionals who are not physicians/doctors but who practice in collaboration with or under the supervision of a physician are included[10,11]. We included studies in which the intervention incorporated eHealth technologies combined with non-physician intervention for BP.

Inclusion criteria:

• Any population-level intervention that employed non-physician interventions in combination with any eHealth component.

• The intervention should at least have a component that could plausibly affect the burden of high BP either by uptake of services or by modifying risk factors.

• The eHealth technology could be to support decision-making by non-physicians or any patient-level intervention such as text messaging, telemonitoring, or mobile application in combination with a non-physician intervention.

• Adults aged at least 18 years and who were hypertensive at baseline were included in the meta-analysis.

Exclusion criteria:

• Studies in which both intervention and usual care groups had an eHealth intervention.

• Interventions in which eHealth interventions were used by the researchers without the engagement of non-physician health workers.

• Interventions delivered solely by specialized health cadres of physicians, but included interventions jointly delivered by physicians and non-physicians and employed at least one eHealth component[12].

• Studies that included fewer than 30 participants, where follow-up was less than three months.

• Studies not published in English.

Data extraction and quality assessment

All articles from the search were exported to Endnote version X9 (Clarivate Analytics, Philadelphia, USA). RT screened the titles and abstracts. RT and WT screened the full text for inclusion. Following the removal of duplicates, the remaining articles were exported to Covidence. We extracted details on BP (mmHg), type of study, disease condition, type of intervention, duration of intervention and eHealth component of the intervention. When there were more than two arms in the intervention, we compared the group in which the intervention consisted of both eHealth component and non-physician health intervention with the usual care group. RT and WT assessed the study quality of included papers in terms of potential bias from randomization, deviation from the intervention, missing outcome, measurement of outcome, and selection of reported results using the Cochrane Risk of Bias Tool 2[13].

We extracted details of primary and secondary outcomes. The primary outcomes for this review are net mean differences in systolic BP (SBP) and diastolic BP (DBP). We conducted a sub-group analysis according to the duration of intervention, type of non-physician health workers, country of research, and type of eHealth intervention.

Statistical analysis

We conducted a meta-analysis of the randomized and cluster randomized controlled trials. We used random effects models to assess the sample average mean difference. Meta-regression was performed to identify the influence of covariates on the effect size. To identify any potential difference in the pooled average effect, sub-group analyses were conducted according to the duration of the intervention, type of intervention, and country income.

Individual study effects and pooled effects were visualized through forest plots using STATA version 16 (StatCorp, College Station, Texas). The I^2 statistic was used to determine whether variation was more likely due to chance or study heterogeneity[14]. The contribution of each study to overall heterogeneity was assessed by omitting one study at a time and recording the change in overall heterogeneity. Publication bias was assessed graphically through contour-enhanced funnel plots and statistically by Egger's regression test[15]. Data were pooled and analyzed using the software Review Manager (version 5.4, the Cochrane Collaboration, Oxford, England). We used the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) framework[16] to rate the quality of evidence for each outcome as high, moderate, low or very low.

RESULTS

The search resulted in 683 studies from three databases. After removing 126 duplicates, we screened 557 articles; 472 were excluded during the title and abstract screening, with 85 papers remaining for full-text review. Four more articles were included from reference searching, and in total, 89 articles were screened for full text. Ultimately, 19 papers fulfilled our eligibility criteria [Figure 1].

The majority of studies were undertaken in the USA (5 studies)[17-21], followed by China (3 studies)[22-25]. Other countries included Argentina[26], Bangaladesh[27], India[23,28], South Korea[29], Ghana[30], Kenya[31], Sweden[32], Australia[33], Jordan[34], and Canada[35]. The follow-up duration ranged from three months[22,24,25,34] to 36 months[32]. Studies on interventions incorporating an integrated approach of eHealth technologies with non-physician health workers were mostly undertaken after 2019. The main characteristics of each study are summarized in Supplementary Table 2.

Type of intervention

The interventions comprised mobile application-based care[22,25,29,30,33,34], telephone-based counselling and monitoring[17,19,21,32], short text messaging[20,26,27,35] and electronic decision-support systems for non-physician health workers[18,20,23,28,31]. The mobile applications were focused on self-monitoring and tracking changes in BP along with lifestyle changes [Supplementary Table 2].

Type of non-physician health workers

Most of the eHealth interventions were led by nurses[17,20,22,25,28,30,32-34] using a combination of education, counselling and telemonitoring. Community health workers were also often employed[21,23,26,27,31,35], but there were few studies that employed pharmacists[19,24], dieticians[18], or exercise coordinators[29] for managing BP.

Effectiveness of intervention in reducing blood pressure

Systolic blood pressure

In total, there were 14, 634 participants from 19 studies (7,277 in intervention and 7,357 in usual care group) pooled for the meta-analysis for SBP. The overall mean SBP reduced by -4.09 mmHg (95%CI: -5.87 to -2.32) for interventions that integrated eHealth technologies with non-physician health workers compared to usual care [Figure 2]. The reduction in SBP varied according to the type of non-physician health workers employed, ranging from -7.59 mmHg for eHealth interventions led by pharmacists, -4.54 mmHg for

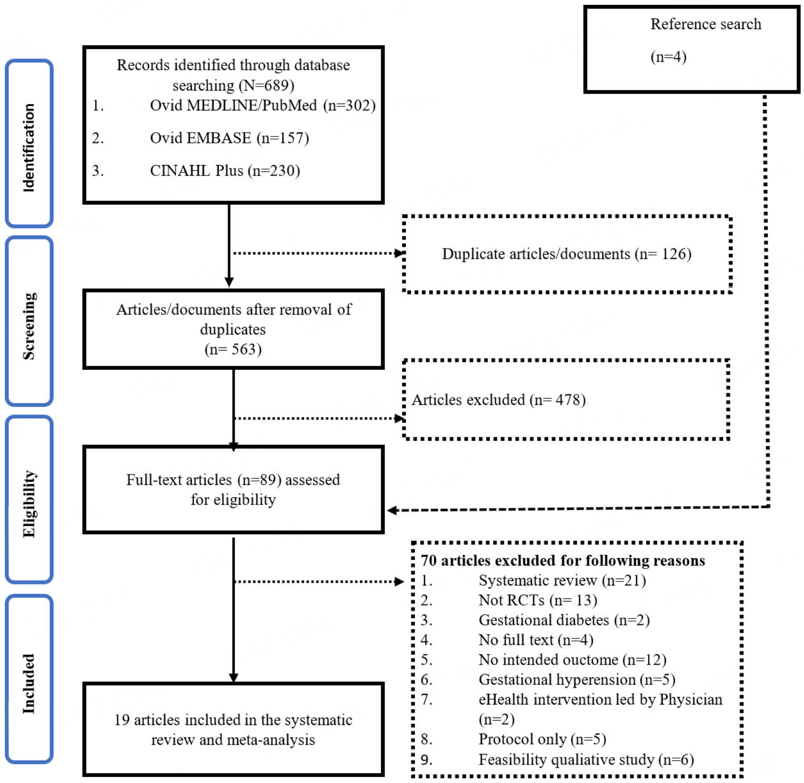

Figure 1. Study selection.

interventions led by nurses to -3.40 mmHg for eHealth interventions led by community health workers. There were only two interventions led by dieticians, with the overall confidence interval crossing the line of no effect. The duration of follow-up ranged from three months to 36 months [Supplementary Figure 1]. Most of the interventions were undertaken for 12 months[17,19-21,23,25,28]. Interestingly, interventions with short follow-up (up to 3 months) had the greatest reduction in BP.

Both mobile application-based intervention and telemedicine comprising telephone-based intervention (video conferencing) resulted in similar reductions in BP. [Supplementary Figure 2]. Non-physician interventions, mainly comprising lifestyle management counselling, BP monitoring and health education combined with short text messaging (SMS), were also found to reduce BP by -3.95 mmHg (-6.38 to -1.51). Five studies[18,20,23,28,31] incorporated eHealth technology to support decisions on medical assessment and adherence patterns and/or provided tailored messages to people with hypertension, with a moderate reduction in SBP [Supplementary Figure 2]. The BP reduction was observed in both high-income and low-income countries, with the greatest reduction observed in middle-income countries [Supplementary Figure 3]. A greater SBP reduction in the intervention group than in the usual care group was observed in both the interventions that directly involved physicians and those without [Supplementary Figure 4].

Diastolic blood pressure

There was a total of 12,016 participants (5,904 in intervention and 6,112 in usual care groups) for the DBP meta-analysis. The overall diastolic BP was reduced by -1.25 mmHg (95%CI: -2.31 to -0.18), more among those in the integrated intervention group than in usual care [Figure 3]. Nurse-led interventions resulted in

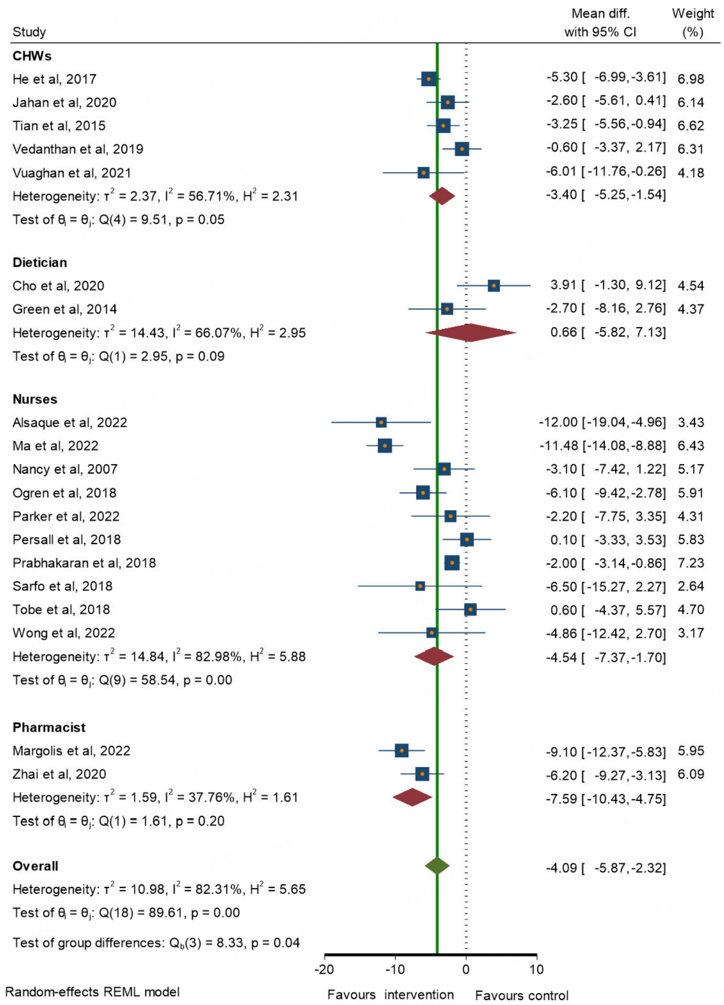

Figure 2. Effectiveness of integrated eHealth technology on systolic blood pressure by type of non-physician health workers. CHWs: community health workers.

the greatest reduction in diastolic BP [-1.85 mmHg (95%CI: -3.14 to -0.55)]. Although interventions lasting more than 12 months were likely to result in greater reductions in BP than the other intervention durations, the confidence intervals were wide and crossed the line of no effect [-2.17 mmHg (95% CI: -5.53 to 1.18)] [Supplementary Figure 5]. Interventions involving non-physician health workers combined with an SMS had the greatest reduction in DBP, but confidence intervals were wide and overlapped the confidence intervals for the other interventions [Supplementary Figure 6]. The reduction in blood pressure did not differ by country income [Supplementary Figure 7]. The DBP reduction was greater for those interventions that were undertaken in combination with active physician intervention than those without direct physician engagement. [Supplementary Figure 8].

Quality of the papers

The methodological quality of the studies varied markedly, with the largest source of potential bias resulting from inadequate information on randomization processes (13 of 19 studies) and reporting of missing data (6 of 19 studies; 34.1%). Most of the studies were open-label or single-blinded and both health care workers and participants were aware of the intervention. However, the outcome measure is objective, so it may not vary by participants' awareness. Selective reporting could not be ruled out in some studies, with no prior

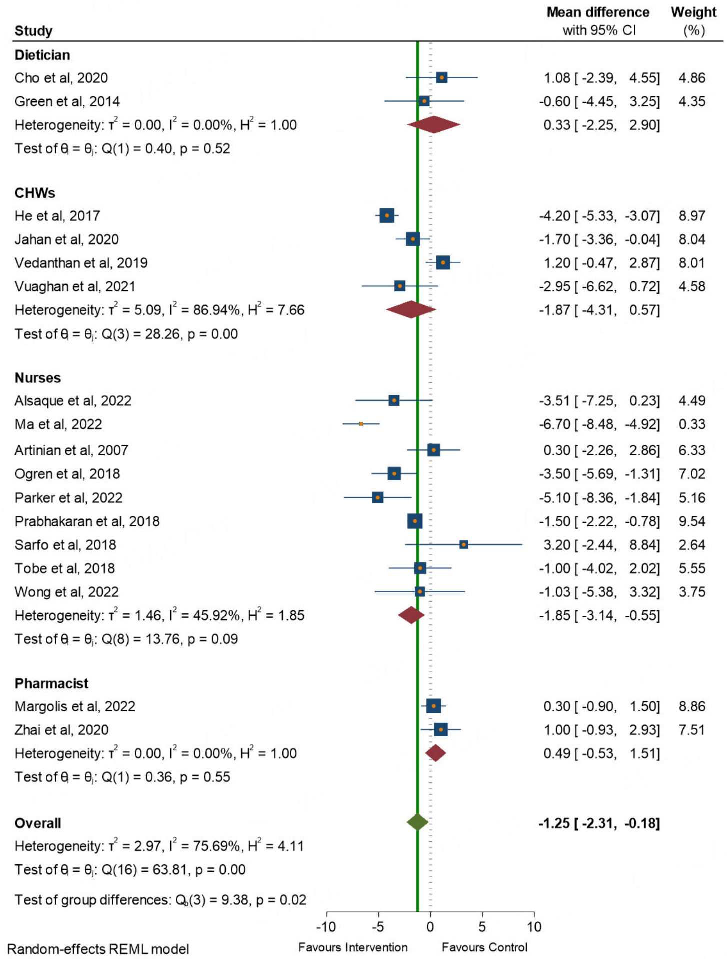

Figure 3. Effectiveness of integrated eHealth technology on diastolic blood pressure by type of non-physician health workers. CHWs: community health workers.

publication of a study protocol. Examination of funnel plots suggests no publication bias for SBP or DBP [Figure 4; Supplementary Figure 9]. The Egger test also showed no publication bias (P = 0.88).

DISCUSSION

Our systematic review and meta-analysis provides a comprehensive synthesis of the evidence of the effectiveness across different types of eHealth technologies integrated with various cadres of non-physician health workers. We show that interventions integrating eHealth technologies with non-physician health workers can effectively reduce SBP and DBP. However, the results are not consistent between different cadres of non-physician health workers. Both mobile-based applications and telemonitoring services were effective in reducing SBP. Even short text messaging combined with BP monitoring by non-physician health workers was found to significantly reduce BP. eHealth interventions were found to be effective both in low-middle- and high-income countries.

Digital technology is increasingly being used in the health sector and is often considered a game changer[20]. The rapid penetration of eHealth technologies throughout the world presents prospects for managing NCDs[20]. The use of technology has been increasing service access and quality, research and monitoring,

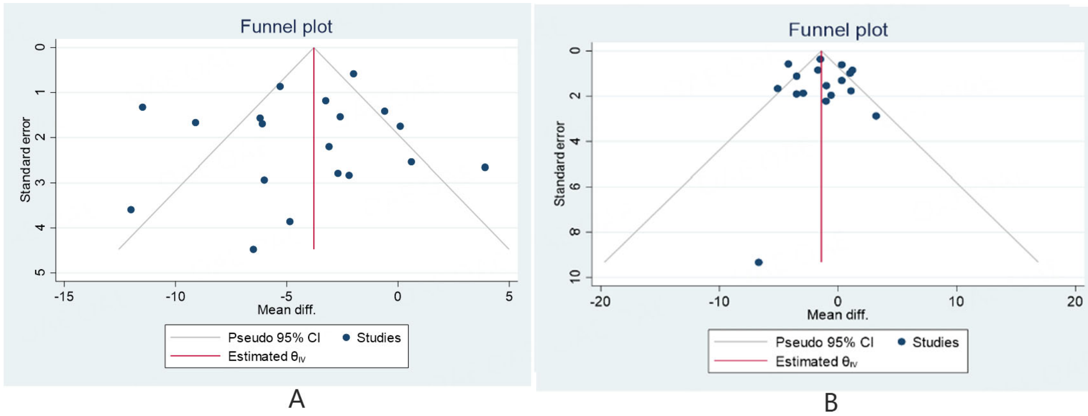

Figure 4. Publication bias for systolic blood pressure (A) and diastolic blood pressure (B).

contact tracking, adherence and decision support[36]. Steinman *et al.* reported that digital health itself is insufficient to address hypertension and diabetes; therefore, in this review, we have assessed the combined effect of non-physician health workers intervention and eHealth technologies[37]. We found that even minimally trained community health workers (CHWs) supported through eHealth were effective in reducing SBP by -3.4 mmHg. Supporting CHWs through a smartphone-based application system to support decisions for tailored lifestyle management, BP monitoring or adherence support was found to be both acceptable and feasible in low-resource settings such as India[23] and Ghana[31]. In other trials, community health worker-led interventions were supplemented through regular text messaging to reinforce the behavioral interventions[26,27]. Community health workers may be often constrained by low literacy or have limited ability to regularly counsel or follow up at physical sites, but we demonstrate the potential benefit of combining CHW interventions with eHealth technologies.

Few studies have combined eHealth technologies with non-physician interventions, particularly in LMICs. Our results underscore the potential benefits of integrating eHealth into comprehensive strategies for the prevention and management of cardiovascular risk factors including hypertension. With the exponential growth of mobile health technology in LMICs in recent years, along with the already existing large cadres of CHWs and other non-physician health workers, there is potential for these integrated interventions to be scaled up. In addition, we were able to show that the greater reduction in SBP (-3.95 mmHg) occurred through telemedicine combined with non-physician health workers, so this adds significantly to prior reviews of digital health interventions alone[38]. However, it should be noted that the effectiveness of the trial may vary in the real-world context depending upon the reach and penetration of the intervention, fidelity and regular monitoring of such intervention. An equally important aspect of such intervention is the upscaling and maintenance of such interventions for sustained benefit[39].

The cost of scaling up such an integrated approach is an important consideration. While few authors have reported that these technology-enabled community health worker interventions were cost-effective and transferrable to other settings using Markov modelling[40,41], there is a need for further cost-effectiveness studies that employ other cadres of non-physician health workers, such as nurses, to enable scaling up such interventions in varying settings. The use of eHealth technologies by health workers surged during and after COVID-19[42]. However, we found a single study that evaluated the public health nursing intervention along with mobile application for self-care and blood pressure in Jordan during COVID-19. The combined intervention showed a significant reduction in blood pressure among the intervention group compared to standard care[34]. Albeit from a limited number of studies, such interventions could potentially be effective in supporting health workers in managing chronic conditions such as hypertension during the time of public health emergencies.

The large reduction of SBP (-4.09 mmHg) that we found overall is clinically meaningful and may lead to significant public health effects at the population level. Even a small reduction of 1 mmHg population-wide SBP has been associated with more than 13 fewer heart failure events per 100,000 person-years[43]. eHealth technologies can be effective tools for supporting non-physicians in decision-making, training of community health workers and other non-physician health workers and augment non-physician care through reinforced messaging and patients' self-monitoring. Both mobile application-based technologies and telemonitoring resulted in similar reductions in SBP. The choice of technology might depend on the cost and complexity of the preferred technology, access to smartphones and digital literacy. We provide evidence that even simple technology such as SMS combined with non-physician health workers can significantly reduce SBP. The growing surge of mobile communication and its potential for behavior change interventions coupled with personalized counselling and monitoring by non-physician health workers can potentially be an effective mechanism in tackling hypertension and other chronic conditions.

Limitations

Our study has some limitations. First, the included studies were diverse, differing in approach, delivery, and outcome measures. There is considerable heterogeneity between the studies. However, using sub-group analyses and sensitivity analyses, we were able to identify potential reasons for heterogeneity. In addition, the diverse settings and interventions increase the likelihood of the findings being scalable and applied to other contexts. Another limitation is that in almost half the studies, there are concerns about the risk of bias. In particular, in most studies, participants and outcome assessors were not blinded to their allocation group. While this is largely due to practical reasons, this may still have introduced some bias. However, the outcomes we assessed were objective measurements, such as changes in BP, which are unlikely to be affected by the assessor's knowledge. We have excluded studies that are not published in English; thus, there is a chance of missing studies from non-English speaking settings. Although the funnel plot showed low chances of publication bias, the probability of under reporting of negative results cannot be ruled out. Finally, we assessed the combined effect of eHealth technology and non-physician health worker intervention, so it may not be possible to distinguish the effect size for individual interventions.

Only two studies[26,28] presented a sub-group analysis according to sex, age or hypertension status; therefore, it was not feasible to perform a meta-analysis according to patients' characteristics or grade of hypertension. Future studies should provide data stratified by the participants' characteristics, as the effects may vary across different sociodemographic and health profiles[44].

Conclusions

This study represents an important step towards expanding the role of integrated eHealth technologies with non-physician health workers in addressing hypertension. Our findings demonstrate the effectiveness of such integrated interventions in reducing BP, highlighting the importance of combining eHealth technology with task-sharing with non-physician health workers to manage NCDs. We recommend scaling up eHealth interventions coupled with task-sharing with non-physicians for the management of BP. Both application-based interventions and simple mobile-based text messaging or telemonitoring can be effective in reducing BP if integrated with management by non-physicians.

DECLARATIONS

Authors' contributions

Conceptualization and design of the study: Thapa R, Thrift A, Zengin A
Extracted the data and performed the statistical analysis: Thapa R
Revision of the data and support in data visualization: Takele WW
Drafted the manuscript: Thapa R
Overall supervision of the study: Thrift A, Zengin A
Critical review and revision of the manuscript: Thrift A, Zengin A
Read and approved the final version of the manuscript: Thapa R, Takele WW, Thrift A, Zengin A

Availability of data and materials

Not applicable

Financial support and sponsorship

None.

Conflicts of interest

All authors declared that there are no conflicts of interest.

Ethical approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

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