

# Cost-Effectiveness of Community-Based Hypertension Prevention Programs: A Systematic Review

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## ABSTRACT

**Introduction:** Community-based hypertension programs are available worldwide. This review aims to summarise the cost-effectiveness of these programs to prevent and control hypertension.

**Material and Methods:** We searched through three databases of PubMed, Scopus and Web of Science in November 2020. Published articles from 2010 through 2020 were screened. The community-based prevention programs were categorised into four groups: self-monitoring, educational interventions directed to the patient, educational interventions directed to the health professional and health professional (nurse or pharmacist) led care.

**Results:** Eleven articles were included in the final review. All 11 articles conducted the programs of education intervention directed towards patients, seven articles conducted programs that include both self-monitoring and health professional (nurse or pharmacist) led care and only two studies conducted programs of which the educational interventions directed to the health professional. Six studies reported as cost per mm Hg reduction in systolic and/or diastolic blood pressure (ranging \$0.69-\$235.7 per mm Hg reduction), two studies reported as cost per DALY averted (ranging \$349-\$582) and three studies reported as cost per QALY gained (ranging \$1257 - \$4219).

**Conclusion:** All studies showed the programs to be cost-effective. This information could provide the evidence base to guide the initiation and development of hypertension programmes.

## KEY WORDS

hypertension, blood pressure, community-based prevention, community healthcare workers

## INTRODUCTION

Hypertension is one of the strongest risk factors for almost all cardiovascular diseases<sup>1</sup>. It is estimated that 1.13 billion people worldwide are currently being diagnosed with hypertension, and two-thirds of them live in low and middle-income countries<sup>2</sup>. In the United States of America, the cost of treating hypertension is about USD51.2 billion per year<sup>3</sup>. Managing modifiable risk factors for hypertension includes high sodium intake, low potassium intake, obesity, alcohol consumption, physical inactivity and unhealthy diet that could help control the blood pressure and prevent the complication<sup>4</sup>.

Effective and targeted intervention to control blood pressure among hypertensive patients and the prevention of hypertension within communities could generate billions of cost savings yearly. Achieving ideal blood pressure reading and preventing hypertension among high-risk groups could generate billions of cost savings every year in healthcare costs. It is projected that by achieving good control of blood pressure in 80% of the hypertensive population could prevent 391,000 cardiovascu-

lar complications. This would result in \$19.8 billion in medical costs prevented (Centre For Disease Control 2020). Team-based hypertension management model involving pharmacists in the United States could prevent up to 115,400 cardiovascular deaths over five years among US adults with uncontrolled high blood pressure. This intervention could save up to \$900 million over five years<sup>5</sup>. Implementing health education involving lifestyle modification to reduce salt intake may reduce hypertension cases by 11 million annually and saves \$18 billion in health care cost<sup>7</sup>.

The described comprehensive management approach of hypertension based on core principle which includes early identification, early diagnosis, early and life-long treatment; application of long-acting and slow-released anti-hypertension drugs to control blood pressure smoothly; use low dosage and combined therapy; individual therapy; lifestyle improvement and enhancing compliance to medication<sup>8</sup>. The public health aspect of prevention and control of hypertension includes early identification, early diagnosis, education, and lifestyle modification. It potentially diminishes hypertension-related morbidity and mortality and curtails health care costs (Ferdinand *et al.*)

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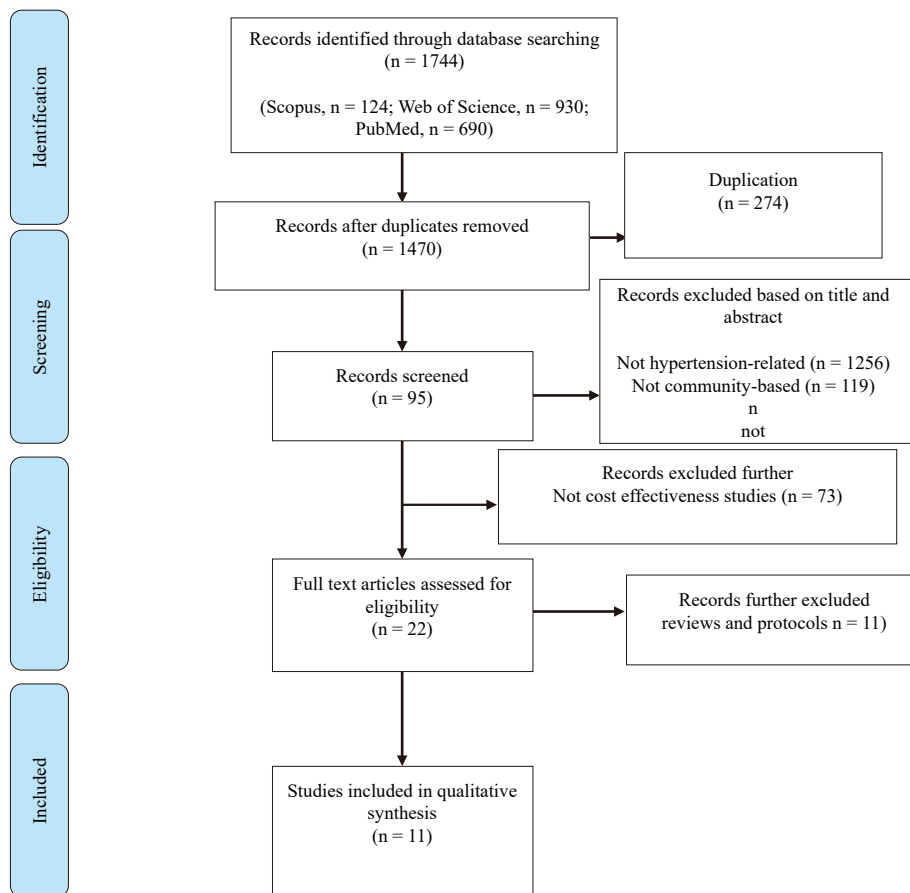


Figure 1: Prisma Flow Diagram

Targeted interventions tailored for hypertensive patients are crucial to improving the quality of life and controlling the blood pressure and reducing and preventing hypertension-related complications. Majority of people are unaware of their status of having hypertension. Even those who have been diagnosed and on treatment, only a proportion of them have their blood pressure reading under control<sup>9</sup>. This gap could have been reduced with the public health approach to managing chronic disease through community-based prevention programs.

Community-based programs that include health screening and health education help improve health outcomes in patients with chronic illnesses, particularly hypertensive patients. Health education as a significant component of effective community-based prevention programs that include lifestyle modifications and adherence to antihypertensive medications to improve blood pressure control in hypertensive patients is well established. This non-pharmacological intervention of improving hypertensive patients' health outcomes has been proven efficient through randomised clinical trial<sup>10</sup>.

In general, the critical aspect of health education that eventually enhance the health literacy among hypertensive and other chronic diseases among patients, not only it improves their knowledge on that particular diseases, but it also contributes to better treatment adherence and patients taking a more positive role in the management of their health<sup>11</sup>. This is called patients' empowerment to improve their health and help physicians better manage their patients. Health posters, health booklets, individualised lecture, and public lectures are standard tools and methods of transferring knowledge through health education. Interactive education workshops could bring forth one of the most effective strategies in community-based health promotion education programs<sup>12</sup>.

This review aims to summarise the evidence of the cost-effectiveness of the community-based hypertension prevention and control programs based on published articles for the past decade. This gathered evidence would provide useful information to policymakers and health practitioners regarding the variety of interventions for improved and better control of hypertension patients in the community.

## METHODS

### Search strategy

We searched through three databases of PubMed, Scopus and Web of Science in November 2020. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) were applied for this systematic review<sup>13</sup>. A comprehensive search strategy was developed using the following keywords: ["hypertension" OR "high blood pressure" OR "blood pressure") AND ("community-based intervention" OR "home health education" OR "educational programmes" OR "self-monitoring" OR "Health promotion") AND ("cost" OR "expenditure" OR "costs" OR "cost analysis" OR "health care costs" OR "cost of illness" OR "benefit" OR "life years" OR "quality-adjusted life years" OR "disability adjusted life years" OR "cost-benefit analysis" OR "cost-effectiveness analysis" OR "cost-utility analysis" OR "economic evaluation")]. The search period covered from 2010 to 2020.

### Selection Criteria

Studies selected were based on these inclusion criteria which include 1) publication in the English language occurred between January 2010 and November 2020; 2) community intervention directed toward patients with hypertension; 3) outcomes were measured as disability-adjusted life years; quality-adjusted life-years gained (QALYs), reduction in per mm Hg systolic and/or diastolic blood pressure; and 4) original cost-effectiveness analysis. Exclusion criteria for this systematic review include 1) Non-community based intervention such as individual-based and pharmacological-based intervention; 2) studies on targeted population studies such as workplace environment; 3) studies related to diseases other than hypertension such as mental health illness and diabetes; 4) studies which do not include an economic evaluation and 5) non-English Articles.

**Table 1: Descriptive analysis of studies included (N = 11)**

Income economies category	Author, Year, Country	Study Design	Types of Community-based Intervention Programs				Consensus Health Economic Criteria Score
			Self-monitoring	Educational interventions directed to the patient	Educational interventions directed to the health professional	Health professional (nurse or pharmacist) led care	
<b>Lower-middle-income economies</b>							
	Jaafar <i>et al</i> , 2011, Pakistan	Randomised controlled trial		√	√		15
	Krishnan <i>et al</i> , 2019, Nepal	Hypothetical population-level model	√	√			16
<b>Upper-middle-income economies</b>							
	Bai <i>et al</i> , 2013, China	Cohort		√		√	15
	Gaziano <i>et al</i> , 2014, South Africa	Hypothetical population-level model		√	√		16
	Augustovski <i>et al</i> , 2018, Argentina	Randomised controlled trial	√	√			17
<b>High-income economies</b>							
	Stoddart <i>et al</i> , 2013, United Kingdom	Randomised controlled trial	√	√		√	15
	Allen <i>et al</i> , 2014, USA	Randomised controlled trial		√		√	14
	Shireman <i>et al</i> , 2016, USA	Randomised controlled trial	√	√		√	16
	Penaloza-Ramos <i>et al</i> , 2016, United Kingdom	Cohort	√	√		√	16
	Monahan <i>et al</i> , 2019, United Kingdom	Randomised controlled trial	√	√		√	16
	Kim <i>et al</i> , 2020, United Kingdom	Randomised controlled trial	√	√		√	16
<b>TOTAL</b>			7	11	2	7	

## Operational definition

Studies selected were classified based on the countries, type of study designs and type of providers involved. The type of community-based intervention programs were further classified based on the framework in a Cochrane systematic review study on the effectiveness of hypertension control interventions<sup>19</sup>. The types of interventions were classified into four groups: 1) self-monitoring; 2) educational interventions directed to the patient; 3) educational interventions directed to the health professional; 4) health professional (nurse or pharmacist) led care. The reported indicators for cost-effectiveness included Cost per mm Hg reduction in systolic blood pressure; Cost per mm Hg reduction in diastolic blood pressure; Cost per averted DALY and cost per gained QALY.

## Data extraction tool

All researchers independently extract the information for each article into an Excel sheet. The data was customised into 1) number; 2) year; 3) author and country; 4) titles 5) study design; 6) type of interventions; 7) the providers' duration of intervention; 8) cost for every reduction of blood pressure per mmHg; 9) cost for every reduction of systolic blood pressure per mmHg; 10) cost for every drop of diastolic blood pressure per mmHg; 11) cost-effectiveness ratio; 12) Disability-adjusted life years (DALY) averted; 13) Quality-adjusted life-year (QALY) gained and 14) conclusion. A second reviewer cross-checked the articles assigned to them and provide comments into the table.

**Table 2: Characteristic of cost effectiveness studies for community-based hypertension control and prevention programs.**

Study: Authors (Year)	Country	Interventions	Comparison	Types of intervention	Provider	Incremental Cost effectiveness Ratio/QALY gained/DALY averted (2018 \$ Value)	Conclusion by authors
Jaafar <i>et al</i> , 2011	Pakistan	2 years of randomised controlled trial of HHE that include the need for moderate physical activity, maintaining ideal body weight, consuming high fibre diet and vegetables and stop smoking plus consultation by trained GP	Standard care	1. Educational interventions directed to the patient 2. Educational interventions directed to the vhealth practitioners	Community health workers; G.P.	\$28.1 (95% CI \$7.3 to \$120.9) per mm Hg reduction in systolic B.P.	Combined HHE plus trained G.P. are more cost effective compared to usual care and either strategy alone
Bai <i>et al</i> , 2013	China	1 year of cohort among hypertensive patients receiving health education	Standard care	1. Educational interventions directed to the patient 2. Health professional (nurse or pharmacist) led care	Physicians; Nurses; Prevention specialists; Pharmacists	\$0.69 per mm Hg reduction in systolic B.P. and \$1.35 per mm Hg reduction in diastolic B.P.	Health education program is cost-effective
Stoddart <i>et al</i> . 2013	U.K. (Scotland)	6 months of randomised controlled trial among hypertensive patients receiving telemonitoring intervention to self-monitor blood pressure using provided validated automated sphygmomanometer	Standard care	1. Self-monitoring 2. Educational interventions directed to the patient 3. Health professional (nurse or pharmacist) led care	G.P.; Practice nurse; District nurse	\$40.9 per mm Hg reduction in systolic B.P. (95% CI \$25.4 to \$75)	Telemonitoring is both more costly and more effective
Allen <i>et al</i> , 2014	USA	1 year of randomised controlled trial among patients receiving tailored educational and behavioral counseling for lifestyle modification, pharmacologic management, and telephone follow-ups between visits	Standard care	1. Educational interventions directed to the patient 2. Health professional (nurse or pharmacist) led care	Nurse; Community Health Workers	\$115.3 per mm Hg reduction in systolic B.P. and \$235.17 per mm Hg reduction in diastolic B.P.	The tailored educational and behavioral program is cost effective
1. Shireman <i>et al</i> , 2016	USA	6 months of cluster randomised trial among black patients with uncontrolled hypertension receiving take-home tool kit for self B.P. monitoring and educational materials to manage hypertension	Standard care	1. Self-monitoring 2. Educational interventions directed to the patient 3. Health professional (nurse or pharmacist) led care	Community pharmacists; Pharmacy technicians	\$26.8 ± 10 per mm Hg reduction in systolic B.P. and \$80.6 ± 278.6 per mm Hg reduction in diastolic B.P.	Community pharmacists can implement a cost-effective intervention to improve hypertension control in blacks.

Kim <i>et al</i> , 2020	U.K.	6 months randomised controlled trial involving 3 groups of patients. Treatment as usual (TAU), Self-monitoring (S-MON) and Self-monitoring and guided self-management of antihypertensive medication (S-MAN).	Standard care (TAU); S-MON	<ol style="list-style-type: none"> <li>1. Self-monitoring</li> <li>2. Educational interventions directed to the patient</li> <li>3. Health professional (nurse or pharmacist) led care</li> </ol>	G.P.; Nurse	\$181 per mm Hg reduction in systolic B.P. (S-MON compared to TAU)	S-MAN is an inefficient intervention. S-MON may be cost effective
Augustovski <i>et al</i> , 2018	Argentina	18 months of cluster randomised trial involving CHW trained to facilitate and educate patients on self-monitoring B.P., lifestyle modification and giving educational materials on hypertension. Patients also received weekly personalised text messages to promote lifestyle changes and reminders to reinforce medication adherence.	Standard care	<ol style="list-style-type: none"> <li>1. Self-monitoring</li> <li>2. Educational interventions directed to the patient</li> </ol>	Community health care workers	\$3,368.58 per QALY and \$26.9 per mmHg SBP reduction	This intervention was cost-effective for blood pressure control among low-income hypertensive patients.
Monahan <i>et al</i> , 2019	U.K.	12 months randomised controlled trials involving 3 groups of patients. Usual care, Self-monitoring and Telemonitoring	Standard care; self-monitoring*	<ol style="list-style-type: none"> <li>1. Self-monitoring</li> <li>2. Educational interventions directed to the patient</li> <li>3. Health professional (nurse or pharmacist) led care</li> </ol>	Nurse	For self-monitoring \$4219.7 per QALY gained. For telemonitoring \$24445 per QALY*	Self-monitoring in clinical practice is cost-effective
1. Penaloza-Ramos <i>et al</i> , 2016	U.K.	1 year cohort study among patients with hypertension given training of self-monitoring blood pressure and self-titrate their antihypertensive medication	Standard care	<ol style="list-style-type: none"> <li>1. Self-monitoring</li> <li>2. Educational interventions directed to the patient</li> <li>2. Health professional (nurse or pharmacist) led care</li> </ol>	Gp; Nurse	\$1257 per 0.21 QALY gained	Self-management of blood pressure in high-risk people with poorly controlled hypertension is cost savings of £830 per patient
Gaziano <i>et al</i> , 2014	South Africa	1. year of community health care worker do home visits to educate patients about healthy lifestyle and treatment adherence	Standard care	<ol style="list-style-type: none"> <li>1. Educational interventions directed to the patient</li> <li>2. Educational interventions directed to the health practitioners</li> </ol>	Community health care workers	\$349.57/DALY Averted	Home visit by CHW is cost effective
Krishnan <i>et al</i> , 2019	Nepal	One-year retrospective analysis involving patients underwent community-based hypertension management programme of blood pressure monitoring and lifestyle counselling intervention	Standard care	<ol style="list-style-type: none"> <li>1. Self-monitoring</li> <li>2. Educational interventions directed to the patient</li> </ol>	Female community health volunteers	\$582 per DALY averted	The programs conducted is cost effective

## Quality assessment and Risk of Bias

The quality assessment and risk of bias of each study selected were assessed based on Consensus on Health Economic Criteria<sup>15</sup>. The criteria consist of 19 items to assess the methodologic quality of economic evaluations which include items of research questions, target population, study design, time horizon, economic evaluation perspectives, cost measurement, cost inflation, outcome measurement, cost discounting, outcome discounting, sensitivity analysis, study generalizability, the potential conflict of interest, and ethical concerns. Two independent reviewers critically appraised all the selected articles. A third reviewer then assessed any discrepancy about the quality.

This review was conducted in 2020. To make incremental cost-effectiveness ratios (ICERs) comparable across the studies, all costs are expressed as 2018 U.S. dollars. The adjustment made was according to purchasing power parity exchange rates and consumer price index from the World Bank<sup>16</sup>.

## RESULTS

### Descriptive analysis

A total of 11 studies regarding the cost-effectiveness of community-based hypertension prevention program were included in the analysis. The articles selected were published from the year of 2011 until 2020. 4 studies were conducted in the U.K.<sup>17-20</sup>, two studies from the USA<sup>21,22</sup> and 1 study each from Pakistan<sup>23</sup>, China<sup>24</sup>, Argentina<sup>25</sup>, Nepal<sup>26</sup> and South Africa<sup>27</sup> (Table 1).

The countries selected were further classified based on income categories according to World Bank Classification categories<sup>28</sup>. The countries were classified into three income country categories. Two studies were in lower-middle-income economies, three studies in the upper-middle-income economies and six studies were in high-income economies.

Study designs included two cohort studies, two modelled designs and seven randomised controlled trials. Quality assessment of all the studies selected was based on Consensus Health Economic Criteria. The score ranges from 14 to 17 out of 19. This showed that all the studies selected were of good studies. Modelled studies and randomised control trials tended to be of higher quality compared to observational studies.

The community-based intervention programs conducted were further classified into four main groups. All 11 articles conducted the programs of education intervention directed towards patients, seven articles conducted programs that include both self-monitoring and health professional (nurse or pharmacist) led care and only two studies conducted programs of which the educational interventions directed to the health professional.

### Cost-effectiveness evidence

Studies selected were reported across four outcomes; Cost per mm Hg reduction in systolic blood pressure; Cost per mm Hg reduction in diastolic blood pressure; Cost per averted DALY and cost per gained QALY (Table 2). 6 studies reported as cost per mm Hg reduction in systolic and/or diastolic blood pressure, two studies reported as cost per DALY averted and three studies reported as cost per QALY gained.

The variation in terms of the cost-effectiveness varies significantly across all 11 studies. The reason is that the studies were conducted in different countries of varying economic backgrounds, targeting different people of multicultural identity across the globe.

For instance, the cost-effectiveness in the reduction of systolic blood pressure reported as low as \$0.69 per mm Hg reduction in China (Bai *et al.*, 2013) compared to \$181 per mm Hg reduction in systolic B.P. in the U.K. (Kim *et al.*, 2020). This huge discrepancy between the two studies contributed by the different calculation of the cost analysis. In China, the cost of drugs was excluded; meanwhile, in the U.K., the cost of antihypertensive medications was included.

The cost-effectiveness reported as cost per DALY averted in Nepal is \$582 per DALY averted and in South Africa is \$349.57/DALY Averted. The gross domestic product per capita for Nepal and South Africa is \$1038 and \$6374, respectively<sup>29,30</sup>. Meanwhile, two studies in the U.K. reported the programs were to be cost-effective at the cost of less than \$4500 per QALY gained and 1 study in Argentina reported \$3,368.58 per QALY gained. The U.K. and Argentina have gross domestic product per capita of \$43,043 and \$11,633, respectively<sup>31,32</sup>.

These showed that the cost per DALY averted and cost per QALY gained do not exceed the annual per capita GDP for both countries, reflecting that the program is indeed cost-effective in the respective countries.

## DISCUSSION

The range of cost-effectiveness of community-based hypertension prevention and control programmes vary widely across countries. It is clear that this discrepancy due to heterogeneity of the study design, cost analysis of individual components of programmes and background economy of countries selected. The type of intervention provided broadly divided into four types. All studies selected incorporate the element of education directed towards patients, and all the programmes were proven cost-effective.

In global health, any intervention leading to per disability-adjusted life-year (DALY) avoided, the cost for implementing the program is less than three times the national annual GDP per capita is considered cost-effective<sup>33</sup>. Should the cost be less than once the yearly national GDP per capita is considered highly cost-effective. This estimation reflects the individuals' willingness to pay for a change in their own risk, averaged throughout the affected population and expressed as a life year's value. GDP per capita is commonly used to estimate the values to the resources available in that particular country<sup>34</sup>.

Education directed tailored to patients includes lifestyle modification, taking a healthy diet inclusive of the right amount of carbohydrate, protein, fat and fibres, low sodium intake, and regular exercise. Strict adherence to the medication prescribed to them is crucial to help the patient maintain and control the blood pressure reading. This has been shown to be cost-effective and randomised controlled trials in Nepal have shown that lifestyle modification effectively reduces the blood pressure among hypertensive patients<sup>35</sup>. Dietary advice as part of the intervention in lifestyle modification in New Zealand to reduce salt intake reported being cost-effective at \$24625 per QALY gained<sup>36</sup>.

More than half of the studies adopted self-monitoring of blood pressure as part of their prevention and control programs for hypertension. It is now increasingly common to educate and empower patients to measure their own blood pressure, usually in a home environment<sup>37</sup>. There are certain occasions which this method requires some additional support such as from a nurse or pharmacist in making sure the blood pressure is monitored accurately. Review has been conducted and proven that self-monitoring is indeed associated with lower and better control of blood pressure. Adding this up with other means of intervention, including education directed to patients and lifestyle counselling leads to clinically significant controlled of blood pressure reading<sup>38</sup>.

A randomised controlled trial conducted for two years among low-income hypertensive and obese patients who self-monitored their own blood pressure proven to be cost-effective and the incremental cost-effectiveness ratio to reduce one mmHg in SBP is \$574<sup>39</sup>. The modelling study done in Utah estimated the incremental cost-effectiveness ratios of self-monitoring of blood pressure are \$767. Its annual cost to save one life-year is predicted to be \$1857 within the ten years<sup>40</sup>.

Community health workers have, indeed played a vital role in community-based prevention programs in general. They are actively involved with enhanced health promotion, especially educating the community regarding lifestyle modification<sup>41</sup>. Their success has historically improved maternal and child health and care for communicable diseases in low middle-income countries<sup>42</sup>. Several studies have been shown this to be effective to control hypertension<sup>43</sup>. Sponsored Internet-based diet and exercise program by the employer for their employees with cardiovascular conditions including diabetes, hypertension and hyperlipidemia over the course of 1 year showed a net savings of US\$827 person<sup>44</sup>. This showed that laypeople could be trained well and yielded a cost-effective intervention to manage non-communicable diseases well.

The community-based prevention programs led healthcare personnel such as nurse and pharmacist are cost-effective. For instance, a 1-year simulation model in which a pharmacist-nurse team involved in a program which involves educating patients with hypertension education brochure managed to control the systolic blood pressure, and it is net savings of \$115(Canadian dollar 2011) per patient in a program lasting for one year<sup>45</sup>.

A randomised controlled trial which involves hypertensive patients receiving nurse-led tailored behavioural intervention bimonthly for two years via telephone has shown to be cost-effectiveness ranged from \$42,457 per life-year saved for normal-weight women to \$87,300 per

life-year saved for normal-weight men<sup>46</sup>).

## LIMITATION

There are few limitations identified in this systematic review. Firstly, from the period of 2010 until 2020, only 11 studies were included from 3 databases. This might not be able to capture other important studies worldwide. Secondly, this warrants a cautious interpretation of the studies selected. The reason is the difference in time horizon across studies ranging from 6 months to modelled over the years. Thirdly, some studies documented the outcome of ICERs as reduction per mm Hg of systolic and/or diastolic, QALY gained per years, or DALY averted per years making comparison across studies were limited.

## CONCLUSION

This systematic review managed to gather credible evidence supporting the community-based intervention programs to prevent and control hypertension to be cost effective and even reduce healthcare costs over time. Countries from various economic backgrounds could use this intervention as a guide to manage hypertension well and reduce the financial burden of managing non-communicable diseases. This review provides the evidence base to guide the initiation and development of hypertension programs.

## CONFLICT OF INTEREST

No potential conflicts of interest relevant to this article were reported.

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