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ORIGINAL RESEARCH

Effectiveness of a School-Based Educational Intervention to Improve Hypertension Control Among Schoolteachers: A Cluster-Randomized Controlled Trial

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BACKGROUND: The control of hypertension is low in low- and middle-income countries like India. We evaluated the effects of a nurse-facilitated educational intervention in improving the control rate of hypertension among school teachers in India.

METHODS AND RESULTS: This was a cluster-randomized controlled trial involving 92 schools in Kerala, which were randomly assigned equally into a usual care group and an intervention group. Participants were 402 school teachers (mean age, 47 years; men, 29%) identified with hypertension. Participants in both study groups received a leaflet containing details of a healthy lifestyle and the importance of regular intake of antihypertensive medication. In addition, the intervention participants received a nurse-facilitated educational intervention on hypertension control for 3 months. The primary outcome was hypertension control. Key secondary outcomes included systolic blood pressure, diastolic blood pressure, and the proportion of participants taking antihypertensive medications. For the primary outcome, we used mixed-effects logistic regression models. Two months after a 3-month educational intervention, a greater proportion of intervention participants (49.0%) achieved hypertension control than the usual care participants (38.2%), with an odds ratio of 1.89 (95% CI, 1.06–3.35), after adjusting for baseline hypertension control. The odds of taking antihypertensive medications were 1.6 times higher in the intervention group compared with the usual care group (odds ratio, 1.62; 95% CI, 1.08–2.45). The reduction in mean systolic blood pressure was significantly greater in the intervention group by 4.2 mm Hg (95% CI, −7.2 to −1.1) than in the usual care group.

CONCLUSIONS: A nurse-facilitated educational intervention was effective in improving the control and treatment rates of hypertension as well as reducing systolic blood pressure among schoolteachers with hypertension.

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Hypertension is the leading risk factor for disability-adjusted life years and deaths globally. In 2019, high systolic blood pressure (SBP) ≥140 mm Hg was attributed to 235 million disability-adjusted life years and 10.8 million deaths worldwide.[1] In 2015, there were 1.13 billion adults with hypertension in the world, and this was an increase from 594 million in 1975.[2] The increase in the number of people with hypertension

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CLINICAL PERSPECTIVE

What Is New?

- This study demonstrated that a nurse-facilitated educational intervention was effective in improving the control and treatment rates of hypertension as well as reducing systolic blood pressure among schoolteachers with hypertension.
- In the usual care group, there was a significant reduction of systolic blood pressure compared with the baseline value probably attributable to the effect of blood pressure measurements and the health education leaflet provided to all teachers regarding the importance of blood pressure control.

What Are the Clinical Implications?

- The trial demonstrated a clinically significant benefit of a short-term educational intervention on improving the control rate of hypertension, improved antihypertensive medication use, and a reduction in mean systolic blood pressure.
- This type of intervention is a feasible solution in resource-poor settings, where there is limited availability of health care infrastructure and manpower, for the control of hypertension.

Nonstandard Abbreviations and Acronyms

CHATS-K	Control of Hypertension Among Teachers in Schools in Kerala
DBP	diastolic blood pressure
HOPE 4	Heart Outcomes Prevention and Evaluation 4
SBP	systolic blood pressure

was more in low- and middle-income countries compared with high-income countries (HICs). Globally, hypertension prevalence was 24.1% in men and 20.1% in women in 2015.[2]

From 2000 to 2010, the rates of awareness of hypertension increased from 58.2% to 67%, of treatment from 44.5% to 55.6%, and of control from 17.9% to 28.4% in high-income countries.[3] In contrast, the increase in the rates of awareness and treatment of hypertension was lower in low- and middle-income countries from 32.3% to 37.9% and from 24.9% to 29.0%, respectively, while the control of hypertension decreased from 8.4% to 7.7% (hypertension control was defined as SBP <140 mm Hg and diastolic blood pressure (DBP) <90 mm Hg among patients with hypertension).[3]

In India, an estimated 199 million adults had hypertension in 2015.[2] In 2016, the prevalence of high SBP among adults in India was 21.1% (men, 20.9%; women, 21.2%),[4] and high SBP contributed to 54% of the cardiovascular disability-adjusted life years.[4] A 2014 systematic review and meta-analysis of 142 studies conducted in India showed that the rate of awareness, treatment, and control of hypertension in rural areas was 25.1%, 24.9%, and 10.7%, respectively. The corresponding figures in urban areas were higher at 41.9%, 37.6%, and 20.2%.[5] In the Indian state of Kerala, studies have shown that these rates were generally higher than the national averages as well as those in many other states.[6–8] For example, a state representative study in Kerala reported awareness of 44.3%, treatment of 36.6%, and control of 13.3%.[9] However, these rates are still suboptimal and lower than the rates reported in many high-income countries,[10] to which Kerala's other health indicators are comparable.

Schoolteachers are role models in many societies, including India, and they are some of the most influential and respected people in society.[11] The study findings from the Tamil Nadu state of India demonstrated that teachers could play a significant role in educating and influencing students' healthy lifestyle practices.[12] However, data on intervention studies on hypertension control among schoolteachers are limited globally.

The present study aimed primarily to evaluate the effects of a nurse-facilitated educational intervention on the control rate of hypertension among schoolteachers in the Kerala state of India.

METHODS

The anonymized data that support the findings of this study are available from the corresponding author upon reasonable request.

Study Design, Setting, and Participants

The CHATS-K (Control of Hypertension Among Teachers in Schools in Kerala) was a prospective cluster randomized controlled trial conducted in 92 schools in rural and urban areas of the Thiruvananthapuram district in Kerala state, India.[13] The Thiruvananthapuram district was chosen for 2 key reasons: its human development index was similar to that of the state,[14] and monitoring was deemed feasible because of its proximity to the institution implementing the research. The study protocol was published previously.[13] Briefly, a baseline survey was conducted to identify participants with hypertension. Since there is no rural-urban difference in most of the health indicators in the state,[8] from the total of 902 schools in the selected district, 92 schools were selected by simple random sampling.[13] Eligible participants comprised consenting male and female teachers aged 30 to 55 years from the selected schools. The retirement age of schoolteachers

in Kerala is 56 years. Since our study was for a period extending up to 1 year, we had set the upper age limit to 55 years. Participants had a good understanding of spoken Malayalam (local language). We selected teachers who reported that they would be in the same school for the next year.

Hypertension was defined as SBP ≥ 140 mm Hg 'and' or 'or' DBP ≥ 90 mm Hg, or self-reported current antihypertensive medication. Controlled hypertension was defined as SBP <140 and DBP <90 mm Hg among people with hypertension. Eligible participants in the trial were those identified as having hypertension in the baseline cross-sectional survey. The enrollment process is detailed in the Figure.

The schools were randomly assigned into 2 equal groups: the usual care group and the intervention group. An educational intervention was implemented in the intervention group for 3 months. After this, a follow-up survey was conducted among the teachers of the usual care group and the intervention group.

Baseline Assessment

A baseline survey was conducted among 2216 schoolteachers from 92 selected schools in the district.[13] Fifteen teachers were randomly selected from schools with 15 to 55 teachers, and for every additional 50 teachers, an extra 15 teachers were selected; and from schools having <15 teachers, all teachers were selected. The World Health Organization (WHO) STEPS questionnaire was administered by trained field staff to collect data on sociodemographic factors, tobacco use, alcohol consumption, physical activity, diet, comorbidities, and medication use.[15] The staff also measured blood pressure (BP), height, weight, and waist and hip circumference using standard equipment as per the World Health Organization protocol.[15] Blood pressure was measured by OMRON BP apparatus, (OMRON HEM-907; OMRON Healthcare Company, Kyoto, Japan) 3 times after the participant had rested for at least 5 minutes before each reading. The average of the second and third readings was taken as the final BP reading. The details of data collection have been published previously,[13] and we have also reported the findings of the baseline survey,[16] which informed the design of this randomized controlled trial for hypertension control.

Randomization and Blinding

The selected 92 schools were randomly assigned into 2 equal groups, an educational intervention and a usual care group, using a computer-generated randomization sequence by a senior statistician based at the study implementing institute. We tried to minimize the effect of contamination by ensuring that the

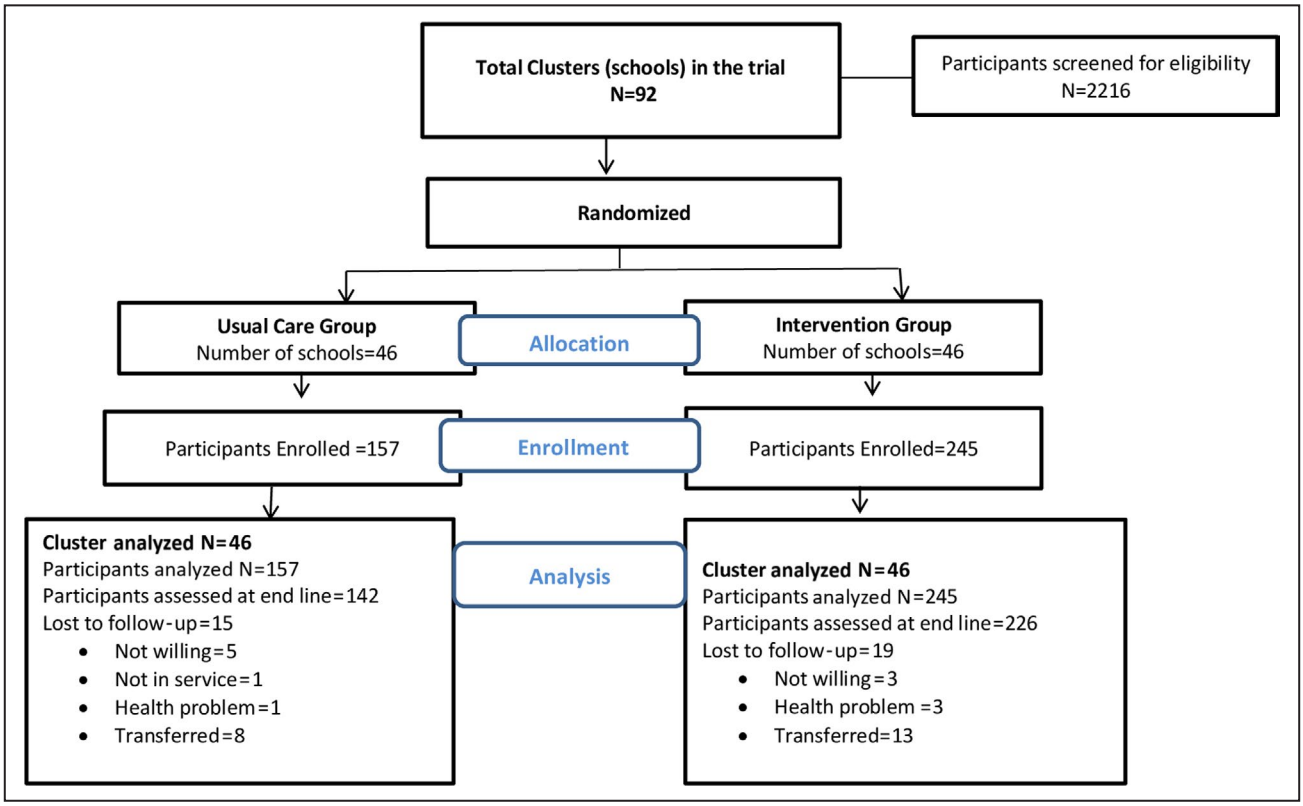

Figure. **Consolidated standards of reporting trials flow of participants.**

schools were geographically separated and the people who delivered intervention were different from those who participated in the baseline and follow-up surveys. The outcome assessors and those involved in data analyses were blinded to the study groups. Those who provided the intervention were different people. Although they were blinded, there was a possibility that a few teachers might have spoken about their experiences of the intervention.

Intervention

A multifaceted intervention was developed and implemented in intervention schools for 3 months. Public health nurses and an intervention manager were trained by the research team (G.K.M., P.S.S., K.R.T.). The trained public health nurses delivered all the intervention components. An intervention manager coordinated and monitored the intervention programs to ensure that the programs were implemented according to the plan and timeline. The intervention mainly aimed to educate schoolteachers about the need for control of hypertension, healthy lifestyle practices, and self-management of hypertension and related noncommunicable diseases and their risk factors. A total of 6 sessions were held in each school. During each session, they were advised on self-management of hypertension including BP monitoring, lifestyle modifications, medication adherence, and how to overcome the barriers of hypertension control. The participants were followed up fortnightly. BP and weight were measured in each of these sessions. Details of the intervention are available in Data S1 and Figure S1.

Usual Care Group

In the usual care group, all participants were informed about their BP, and their anthropometric measurements were obtained during the baseline survey. Those who were identified to have hypertension in the baseline survey were advised to check their BP with a health care provider for confirmation and follow-up with them for further management, if necessary. Usual care participants were given educational material on hypertension and its risk factors. We did not give any other intervention to the usual care group.

Study Outcomes

The trial's primary outcome was the rate of control of hypertension evaluated 2 months after a 3-month educational intervention. The primary outcome measurement was done using a standard protocol suggested by the World Health Organization,[15] ensuring the quality and reproducibility. Secondary outcomes were change in antihypertensive medication use rate, SBP and DBP, anthropometrics, diet, and physical activity. A follow-up survey was done after completing the intervention in both the usual care and intervention groups. Follow-up was carried out 2 months after the intervention to see whether the effect of intervention persisted after 2 months. Questionnaire administration and measurements were similar in the baseline and end-line survey for both the usual care group and intervention participants. The response rate was 91.5%. Details are provided in the Figure.

Sample Size

One study reported a control rate of hypertension in Kerala as 13.5%.[8] We expected an increase of 1% in the hypertension control rate in the usual care group (13.5%–14.5%) and an increase of 11.5% in the intervention group (13.5%–25%) after the intervention. Based on this, the sample size was estimated as 330 teachers with hypertension in each group to achieve 80% power; alpha error, 5%, loss to follow-up, 10%; and a design effect of 1.3. Based on an anticipated hypertension prevalence of 30%,[9] we had to conduct a baseline screening survey among 2200 teachers from 92 schools (clusters) to identify 660 teachers with hypertension.[13]

Ethical Considerations

We obtained ethical clearance from the ethical committee of the Sree Chitra Tirunal Institute for Medical Sciences and Technology, Kerala, India. This trial was prospectively registered with the Clinical Trials Registry of India [CTRI/2018/01/011402]. We advised people identified with high BP (SBP ≥140 or DBP ≥90 mm Hg) to seek medical advice from their regular health care providers or the nearest primary health center/government health facility. Privacy was maintained in administering questionnaires and physical measurements. Informed written consent was obtained from all participants at each stage of the study.

Statistical Analysis

The baseline characteristics of participants are summarized using mean (SD) or median (interquartile range) for continuous variables and by frequency and percentage for categorical variables.

We performed both complete case and intention-to-treat (ITT) analyses. For the ITT analyses, the missing data for the primary and secondary outcomes of 34 participants (8.5%) who were lost to follow-up were imputed using the last observation carried forward under the missing at random assumption. Since the results of ITT and complete case analysis were similar, we present the results of ITT in the main text and complete case analyses in Tables S1 through S3.

For the primary outcome, we used mixed-effects logistic regression models, accounting for clustering of

Table 1. Baseline Characteristics of Participants by Study Group

Characteristics	Usual care	Intervention group
	157	245
Demographics		
Age, y, mean±SD	46.3±5.2	47.5±5.3
Female, n (%)	109 (69.4)	175 (71.4)
Education, n (%)		
Higher secondary/technical	9 (5.7)	39 (15.9)
Graduate	53 (33.8)	66 (26.9)
Postgraduate	95 (60.5)	140 (57.1)
Type of school, n (%)		
Government	70 (44.6)	134 (54.7)
Private	87 (55.4)	111 (45.3)
Marital status, n (%)		
Married	142 (90.5)	221 (90.2)
Others*	15 (9.6)	24 (9.8)
Religion, n (%)†		
Hindu	92 (59.0)	154 (63.9)
Muslim	11 (7.1)	12 (5.0)
Christian	53 (34.0)	75 (31.1)
Teaching section, n (%)		
LP/UP	44 (28.0)	73 (29.8)
HSA	77 (49.0)	133 (54.3)
HSS/VHSE	36 (22.9)	39 (15.9)
Behavioral factors		
Current tobacco use, n (%)	0 (0)	8 (3.3)
Current alcohol use, n (%)	11 (7.0)	16 (6.5)
Adding extra salt to food, n (%)	9 (5.7)	13 (5.3)
Weekly servings of fruits and vegetables, median (IQR)	8 (2–10)	9 (2–11)
Physical activity		
MET-min/wk, median (IQR)	240 (0–620)	310 (0–600)
≥600 MET-min/wk, n (%)	44 (28.0)	76 (31.0)
Clinical measures		
Weight, kg, mean±SD	70.5±10.8	68.2±10.7
Body mass index, kg/m^2, mean±SD	28.2±4.6	27.4±4.4
Waist circumference, cm‡	103.9±8.1	102.3±8.3
Waist-to-hip ratio§, mean±SD	1.08±0.07	1.10±0.07
Systolic BP, mm Hg, mean±SD	134.4±16.3	136.2±18.0
Diastolic BP, mm Hg, mean±SD	87.7±9.6	87.8±10.6
Taking antihypertensive medications, n (%)	76 (48.4)	122 (49.8)
Hypertension control‖, n (%)	50 (31.9)	87 (35.5)

(*Continued*)

Table 1. Continued

Characteristics	Usual care	Intervention group
	157	245
Medical and family history		
Diabetes, self-reported, n (%)	24 (15.3)	56 (22.9)
High cholesterol, self-reported, n (%)	46 (29.3)	80 (32.7)
Family history of diabetes, n (%)	113 (72.0)	175 (71.4)
Family history of hypertension, n (%)	113 (72.0)	184 (75.1)

BP indicates blood pressure; HSA, high school assistant; HSSA, higher secondary school assistant; IQR, interquartile range; LP, lower primary; MET, metabolic-equivalent task; UP, upper primary, and VHSE, vocational higher secondary education.

*Includes never married, separated, divorced, widowed, and cohabiting.

†Missing for 1 participant in the intervention group and for 4 participants in the usual care group (in both intention-to-treat and complete case samples).

‡Missing for 1 participant in the intervention group and for 1 participant in the usual care group (in both intention-to-treat and complete case samples).

§Missing for 1 participant in the intervention group and for 1 participant in the usual care group (in both intention-to-treat and complete case samples).

‖Control of hypertension was defined as systolic BP<140 mm Hg and diastolic BP<90 mm Hg with the use of antihypertensive medications.

participants within schools and adjusting for baseline hypertension control. Results are presented as odds ratios (ORs) (and 95% CIs and *P* values).

For continuous secondary outcome variables, we used mixed-effects linear regression models, accounting for clustering of participants within schools and adjusting for baseline values. Study group (intervention versus usual care), time point (follow-up versus baseline), and a study group–by–time point interaction were specified as fixed effects. Random effects were specified for schools to account for the clustered study design and for participants to account for the correlation between the repeated measurements on the same individual. *P* value of the study group–by–time point interaction was used to test the difference in mean change in outcomes between study groups. For categorical secondary outcomes, mixed-effects logistic regression models were used. We calculated the intraclass correlation coefficient for the primary and secondary outcomes using the postestimation command "estat icc" in Stata software (StataCorp, College Station, TX). For the primary outcome, as a sensitivity analysis, we adjusted for variables that seemed to be meaningfully different between study groups at baseline. We did not adjust for multiplicity, as there was only 1 primary outcome and the findings for secondary outcomes are considered exploratory.[17] A 2-tailed *P* value of <0.05 was considered statistically significant. Data were analyzed using Stata/MP version 16.1.

Table 2. Effectiveness of Intervention on Control of Hypertension in People With Hypertension: Results Based on Intention-to-Treat Analysis

Study time	Usual care group, n/N (%)	Intervention group, n/N (%)	Odds ratio (95% CI)†	*P* Value	ICC
Baseline	50/157 (31.9)	87/245 (35.5)	1.89 (1.06, 3.35)	0.030	0.12
3 mo	60/157 (38.2)	120/245 (49.0)			

ICC indicates intraclass correlation.
*Odds ratio was obtained from mixed-effects logistic regression models, accounting for clustering of participants within schools and adjusting for baseline hypertension control.

RESULTS

We screened 2216 schoolteachers from 92 schools and identified 402 teachers with hypertension implying a hypertension prevalence of 18.1%,[16] much lower than anticipated. We randomly assigned 92 schools equally into usual care and intervention groups using computer-generated random sequences. In the follow-up survey, 6% migrated, 1% reported inconvenience to participate during the follow-up period, and the remaining 1% were under treatment for other diseases and did not give consent to participate. Therefore, we were able to contact 92% of the teachers during the follow-up survey.

The average age of the participants was 47 years (range, 30–55), 29% were men, and 90% were currently married. More than half (51%) of the teachers were from government schools, and the remaining 49% were from government-aided private schools. Fifty-nine percent had postgraduate education, and 41% were graduates or had other technical qualifications. Current tobacco use was reported by 2% and alcohol use by 7% of the participants. Use of extra salt to food was reported by 5%, and the median servings of fruits and vegetables per week was 8. Around 70% were found to be inactive (<600 metabolic equivalent tasks-min/week). The baseline characteristics of the study groups are well balanced between study groups, except for education, type of school, and medical history of diabetes (Table 1).

The control rate of hypertension at baseline was 31.9% in the usual care group and 35.5% in the intervention group. We found a significantly improved change in hypertension control rate among all individuals with hypertension in both of the study groups, with a greater rate of improvement in the intervention group (49%) compared with the usual care group (38%). Teachers with hypertension in the intervention group were nearly 2 times more likely to achieve adequate control of hypertension compared with those in the usual care group (OR, 1.89; 95% CI, 1.06–3.35), after adjusting for baseline control of hypertension (Table 2). Similar results were found in complete case analysis (Table S1) and also after adjusting for baseline control of hypertension and variables that were different between study groups at baseline (Table S2).

There was a significant reduction in SBP in both the usual care and intervention groups from baseline to follow-up period (Table 3). An SBP reduction of 8.0 mm Hg in the intervention group was significantly higher than the 3.8 mm Hg in the usual care group. Although there was a significant reduction in DBP in the postintervention survey in both the usual care and the intervention groups, the difference between the groups did not reach statistical significance. There was a significant increase in pharmacological treatment in postintervention in both the usual care and intervention groups. After the intervention, a larger proportion of intervention group participants used antihypertensive medicines compared with the usual care group (OR, 1.62; 95% CI, 1.08–2.45).

We found a statistically significant net change in the mean servings of fruits and vegetables per week between the usual care group and the intervention group (12 versus 16 servings) from baseline to the follow-up survey (Table 3). Teachers in the intervention group were 4 times more likely to consume adequate fruits and vegetables compared with those in the usual care group. There were no significant changes in other secondary outcomes.

ITT results are similar to those from the complete case analyses (see Table S3).

DISCUSSION

The results of this cluster randomized controlled trial among schoolteachers indicate that a short-term, educational intervention program was effective in increasing the hypertension control rate among teachers with hypertension. There was a significant reduction of SBP in both the usual care and intervention groups, and the reduction in the intervention group was significantly higher than that of the usual care group.

In our study, the proportion of those who improved their hypertension control rate in the intervention group of 49% was lower than the 64.8% reported in the HOPE 4 (Heart Outcomes Prevention and Evaluation 4) study among the general population.[18] The higher control rate in the HOPE 4 study could be attributable to the inclusion of counseling and free antihypertensive medications under the supervision of physicians with support from family/friends. Moreover, the intervention duration

Table 3. Changes in Risk Factors From Baseline to Follow Up Period Among People With Hypertension in the Intervention and Usual Care Groups: Results of Intention-to-Treat Analysis

Risk factors	Usual care group	Intervention group	Difference (95% CI) or odds ratio (95% CI)‡	*P* Value	ICC
	Mean change from baseline to 3 mo (SD) or n/N (%)	Mean change from baseline to 3 mo or n/N (%)			
Weight, kg	0.54 (6.84)	−0.01 (5.73)	−0.55 (−1.76 to 0.67)	0.38	0.22
Body mass index, kg/m^2	−0.05 (4.58)	−0.16 (3.62)	−0.10 (−0.83 to 0.62)	0.78	0.10
Waist circumference, cm	−6.20 (8.50)	−6.40 (9.22)	−0.17 (−1.84 to 1.50)	0.84	0.10
Waist-to-hip ratio	−0.11 (0.12)	−0.09 (0.13)	0.020 (−0.002 to 0.041)	0.07	0.13
MET-min/wk	99.42 (567.74)	86.94 (590.46)	−12.48 (−118.47 to 93.50)	0.82	0.03
Physically active, ≥600 MET-min/wk					0.02
Baseline	44 (28.0)	76 (31.0)	1.04 (0.64 to 1.68)	0.87	
3 mo	56 (35.7)	86 (35.1)			
Fruit and vegetable servings/wk	12.00 (13.63)	16.08 (18.46)	4.07 (0.93 to 7.22)	0.011	0.09
Systolic BP, mm Hg	−3.8 (14.3)	−8.0 (17.8)	−4.2 (−7.2 to −1.1)	0.007	0.09
Diastolic BP, mm Hg	−3.1 (9.7)	−4.4 (11.7)	−1.3 (−3.3 to 0.8)	0.22	0.10
Taking antihypertensive medications					0.19
Baseline	76 (48.4)	122 (49.8)	1.62 (1.08 to 2.45)	0.021	
3 mo	85 (54.1)	161 (65.7)			

BP indicates blood pressure; ICC, intraclass correlation; and MET, metabolic equivalent task.

*Difference in mean change in continuous variables between study groups and odds ratio were obtained using mixed-effects linear regression and logistic regression models, respectively, accounting for clustering of participants within schools and adjusting for baseline values.

in the HOPE 4 study was 1 year, while the intervention was only for 3 months in our study. However, a recent cluster-randomized pilot clinical trial using digital medicine offering (including digital medicines, a wearable sensor patch, and a mobile device app) reported a significant reduction in SBP in the intervention group of patients within 4 weeks[19] A smartphone-enabled management package for hypertension was found to be effective in improving BP values in primary health care facilities in India.[20] Another study using nonphysician health workers with the help of technology was found to be effective in improving hypertension control in a demonstration project in Telangana state of India.[21]

Our study showed significant improvement in the proportion of participants with hypertension on antihypertensive medication in both groups, which is similar to that reported earlier[18] and in contrast to a study from rural India that reported no significant change in antihypertensive medication after the intervention.[22] Even among the usual care group of participants, there were significant improvements in medication and hypertension control rates. This indicated that even providing minimal information through education material and one-time measurement of BP, control rates of hypertension can be improved in an educated population like schoolteachers. When the BP was measured, the reading was communicated to the teachers, and if this was higher, there would be some efforts from the teachers to reduce their BP. This could be replicated in the general population of Kerala, the state with the highest literacy rate of 96% in India.[23] As per the latest community-based survey in Kerala, 1 in 3 adults had hypertension, and the control rate of hypertension was 13.5%,[8] which was much lower compared with the control rates of the United Kingdom, the United States, and Canada.[24] In contrast, some other health indicators of the state, like infant mortality and life expectancy, are almost similar to those of developed countries. Uncontrolled hypertension is a very serious public health problem, particularly in a state where good health at low cost has emerged as a global model.[25]

Even in the usual care group, there was a significant reduction of SBP compared with the baseline value probably attributable to the effect of BP measurements and the health education leaflet provided to all teachers regarding the importance of BP control. A reduction in mean SBP of 4.9 mm Hg attributable to task-sharing intervention was reported in a systematic review and meta-analysis from developing countries among the general population.[26] Our finding on the increase of hypertension control using nonphysician health educators is comparable to the above study findings of an overall reduction in SBP resulting from task-sharing interventions for hypertension management. A higher BP reduction was also reported among adults aged ≥40 years in Brazil.[27] Our result of the significant decrease in SBP in the intervention group compared with the usual care group was similar to the findings among the general population from developed countries.[28] The meta-analysis of randomized controlled trials on pharmacological BP lowering interventions in 2021 reported that an SBP reduction of 5 mm Hg reduced the risk of a cardiovascular event by 10%, stroke 13%, heart failure 13%, ischemic heart disease 8%, and cardiovascular death 5%.[28]

We did not find significant improvements in the behavioral risk factors of hypertension, except for fruit and vegetable intake, during the trial period, probably because our trial was underpowered for these secondary end point outcomes for subgroup analysis. Similar findings were reported from Colombia, Malaysia,[18] and India.[29] This needs to be further explored with long-term intervention trials.

One-time monitoring of BP and providing an educational leaflet resulted in improved hypertension control rate and pharmacological treatment for hypertension even among the usual care group of teachers. We were unable to determine the exact factors that influenced the improved control rate of hypertension and the pathways that helped to improve the control rate other than the increase in medication. Also, the long-term sustainability of the effect of the intervention cannot be ensured. However, the study was designed to measure the intervention program's short-term effect on BP control among schoolteachers in Kerala. The high level of awareness and knowledge on the control of hypertension in the study group likely played a significant positive role in implementing the educational intervention. The high levels of affordability of antihypertensive medications among the participants also helped implement the intervention components. Our findings open up the way for scale-up of behavioral interventions in similar educated groups and institutional settings to improve hypertension control rates. Our finding underscores the role of teachers in promoting health education programs, with a promising task-shifting or task-sharing approach in reducing BP.[26] The government and government-aided private schools in Kerala are provided with the services of a frontline health care worker, and this person can be trained to provide these interventions without many additional resources, making this intervention sustainable.

Strengths and Limitations

To our knowledge, this is the first randomized controlled trial to evaluate the effectiveness of a short-term nurse-facilitated educational intervention program to improve BP control in schoolteachers. The study demonstrated that a nurse-facilitated educational intervention was effective in significant improvement in control

of hypertension, improved antihypertensive medication use, and reduction in mean SBP. Since our participants were teachers recruited from schools in Kerala, these findings indicated an upper level of hypertension control in the study setting with a short-term intervention program. Our findings add to the limited literature on the control of hypertension among the educated group, especially schoolteachers, who can play a major role in children's health behavior and society at large.

As the teacher strength in the schools was not uniform across schools, from 46 schools in the usual care group, 157 teachers were eligible, and from the 46 intervention schools, 245 teachers were eligible and were recruited. We could reach only 61% of the targeted sample size of teachers with hypertension since the hypertension prevalence among the teachers was lower than anticipated and attributable to funding and time constraints. However, with the recruited sample, we were still able to demonstrate clinically significant improvements in the primary and some key secondary outcomes, albeit with wider CIs. The possibility of unintentional communication between teachers in the intervention and usual care groups was unlikely to influence the outcome significantly. Given the nature of the intervention, it was not possible to blind those delivering the intervention. The generalizability of our study findings to the general population is uncertain mainly because of the high educational status and higher affordability of our participants for antihypertensive medications. However, the availability of educational interventions on the control of hypertension in India is limited. Future studies with a larger sample might be useful to confirm our findings. The improved BP control among the usual care group is likely to be attributable to a combination of greater use of BP-lowering medication as well as the possibility of regression to mean. Finally, the study was adequately powered only for the primary outcome, so the findings for secondary outcomes should be considered as exploratory.

CONCLUSIONS

The trial demonstrated a clinically significant benefit of a short-term educational intervention on improving the control rate of hypertension, reduction in SBP, and an increase in pharmacological treatment compared with usual care. The health systems may use schoolteachers as ambassadors to promote a healthy lifestyle and improve the control of hypertension. All schools in Kerala have parent-teacher associations. Teachers can use this platform to educate the parents about healthy lifestyles, which can be further expanded to grandparents.

ARTICLE INFORMATION

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Disclosures

None.

Supplemental Material

Data S1
Tables S1–S3
Figure S1

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Supplemental Material

Data S1.

Supplemental Methods

Development and implementation of the intervention

The process and implementation involved three steps. Firstly, we developed an intervention program based on the baseline survey findings, literature review, and discussion with implementation experts. The participant's behavioural practices, including barriers to and facilitators of hypertension management, were analysed using the baseline survey data. The conceptualization of the construct of intervention components was made by an expert panel supported by the literature review of existing intervention programs. We also adopted specific components of successful models on prevention and control of hypertension and relevant intervention components from similar NCD prevention programs conducted in the state.[9] We considered inputs from educational experts during the development of the intervention. This resulted in a pool of a list of intervention components to educate the need for control of hypertension like healthy lifestyle practices and self-management of hypertension and related NCDs and their risk factors. Briefly, we planned education classes on control of hypertension and other lifestyle risk factors, education materials such as pamphlets and educational videos, and interactive sessions at schools. Together with the above components of the intervention, we planned the feasibility of using the short message service (SMS) for educational intervention on hypertension control, regular blood pressure monitoring, and advice on medication.

In the second step, we piloted the above intervention components' feasibility in five percent of the total schools included in the baseline survey. We also asked about the feasibility of sending healthy lifestyle messages to control hypertension through a WhatsApp group. A large majority (98%) opted out of education classes, presentations, and SMS. They chose to have a regular measurement of BP and showed a willingness to be part of the WhatsApp group. After piloting the intervention, we identified that the conventional intervention components do not apply to the educated groups like school teachers. So, we finalized the intervention components to education materials, regular monitoring of BP, advice on medication, and health education through the WhatsApp group. Finally, the intervention session was designed with self-management education, with continued support from the research team.

Finally, all eligible participants for the baseline survey, who were aware of being hypertensive or on medication for hypertension, were contacted. We implemented the multi-component intervention strategy in all intervention schools. All intervention components were delivered through trained public health nurses (women with a general nursing degree) via the intervention manager (a post-graduate social scientist). The research team gave training to the nurses and the intervention manager. The nurses delivered the intervention to teachers at schools under the supervision and monitoring of the intervention manager and the research team.

We delivered the intervention to all teachers in the selected schools, and measured BP and gave specific advice on the control of hypertension and the importance of regular medication to teachers with hypertension, and also advised on healthy lifestyle practices for better hypertension management. We conducted meetings on a fortnightly basis for three months (six sessions). We used booklets prepared for the NCD program for teachers in Kerala and used the music videos on the four major NCD risk factors such as tobacco, alcohol, unhealthy diet, and physical inactivity.[9] Interactive sessions at schools were conducted using these

educational materials. All teachers in the intervention schools were given WHO materials (printouts) on the control of hypertension. The specific intervention was given to participants of the trial. Each meeting was divided into two approximately 30-minute sessions. During the first part, we measured participants' blood pressure and weight, and collected details on the barriers to controlling hypertension. The next part was comprised of an education component, including advice on healthy lifestyles and regular medication. Finally, the participants were given time to share their experiences on hypertension management.

A WhatsApp group was formed including all teachers with hypertension in the intervention schools. The research team regularly sent messages on hypertension control, the importance of taking medication, and other lifestyle modification messages through WhatsApp. The team also shared videos on risk factors of hypertension (tobacco, diet, physical activity, and alcohol). We also clarified doubts and answered questions from the group members through WhatsApp.

Table S1. Effectiveness of intervention on control of hypertension in people with hypertension: Results of complete case analysis.

Study Time	**Usual care group (n/N (%))**	**Intervention group (n/N (%))**	**Odds ratio (95% CI)***	**P value**
Baseline	45/142 (31.7)	80/226 (35.4)	1.88 (1.05, 3.37)	0.032
3 months	55/142 (38.7)	113/226 (50.0)		

CI, confidence interval. *Odds ratio was obtained from mixed-effects logistic regression models, accounting for clustering of participants within schools and adjusting for baseline hypertension control.

Table S2. Effectiveness of intervention on control of hypertension in people with hypertension: Results of sensitivity analysis (ITT analysis).

Study Time	Usual care group (n/N (%))	Intervention group (n/N (%))	Odds ratio (95% CI)*	P value
Baseline	50/157 (31.9)	87/245 (35.5)	1.94 (1.04, 3.65)	0.038
3 months	60/157 (38.2)	120/245 (49.0)		

CI, confidence interval; ITT, intention-to-treat. *Odds ratio was obtained from mixed-effects logistic regression models, accounting for clustering of participants within schools and adjusting for baseline hypertension control, age, sex, education, school type, religion, teaching section, current tobacco use, physical activity, fruit and veg intake, weight, self-reported diabetes, self-reported high cholesterol, and family history of hypertension.

Table S3: Changes in risk factors from baseline to 3 months among people with hypertension in the intervention and control groups: Results of complete case analysis.

	Usual care group	**Intervention group**		
	Mean change from baseline to 3 months (SD) or n/N (%)	**Mean change from baseline to 3 months or n/N (%)**	**Difference (95% CI) or Odds ratio (95% CI)***	**P value**
Weight (kg)	0.59 (7.20)	-0.01 (5.96)	-0.60 (-1.93, 0.72)	0.37
Body mass index (kg/m^2)	-0.06 (4.82)	-0.17 (3.77)	-0.11 (-0.90, 0.68)	0.78
Waist circumference (cm)	-6.86 (8.68)	-6.96 (9.40)	-0.05 (-1.83, 1.72)	0.95
Waist-to-hip ratio	-0.12 (0.12)	-0.09 (0.13)	0.024 (0.001, 0.046)	0.037
MET-min/week	109.92 (596.20)	94.25 (614.32)	-15.67 (-130.85, 99.51)	0.79
≥600 MET-min/week Baseline 3 months	 42 (29.6) 54 (38.0)	 66 (29.2) 76 (33.6)	 1.20 (0.73, 1.96)	 0.48
Fruit and vegetable servings/week	13.27 (13.73)	17.43 (18.60)	4.16 (0.86, 7.45)	0.013
Systolic BP (mmHg)	-4.2 (14.9)	-8.6 (18.4)	-4.4 (-7.7, -1.2)	0.008
Diastolic BP (mmHg)	-3.4 (10.1)	-4.7 (12.2)	-1.3 (-3.5, 0.9)	0.24
Taking anti-hypertensive medications Baseline 3 months	 69 (48.6) 78 (54.9)	 122 (49.6) 151 (66.8)	 1.65 (1.07, 2.54)	 0.023

SD, standard deviation; CI, confidence interval; BP, blood pressure; MET, metabolic equivalent task. *Difference in mean change in continuous variables between study groups and odds ratio were obtained using mixed-effects linear regression and logistic regression models, respectively, accounting for clustering of participants within schools and adjusting for baseline values

Figure S1. Details of intervention given to usual care and intervention group.