Effect of Financial Incentives on Hypertension Control: A Multicenter Randomized Controlled Trial in China

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BACKGROUND: Poorly controlled hypertension is a great challenge to global public health. Incentive approaches, based on behavioral and economic concepts, may improve patients’ adherence to treatment.

METHODS: We conducted a 2-arm randomized controlled trial to test whether financial incentives can help patients with poorly controlled hypertension in China reduce their blood pressure (BP). Participants were randomized 1:1 to the control and intervention groups. All participants received WeChat-based standard education and support for hypertension management. The intervention group received financial incentives, including process- and outcome-based incentives.

RESULTS: No statistically significant differences in BP reduction and hypertension control rates were found between the two groups from baseline to 12-month follow-up. Mean systolic BP decreased from 158.7 to 149.8 mm Hg in the intervention group and 159.7 to 149.5 mm Hg in the control group (P=0.639). Mean diastolic BP decreased from 93.7 to 86.6 mm Hg in the intervention group and 93.9 to 86.3 mm Hg in the control group (P=0.667). Hypertension control rates in the intervention group and 86.2% in the control group (P=0.705).

CONCLUSIONS: Financial incentives were effective in the short term for BP control, but a sustained effect of incentive-based BP control was not identified beyond 3 months of intervention. Future studies that focus on identifying the appropriate amount and structure of financial incentives for BP control are warranted.

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Hypertension is a global public health challenge and a major modifiable risk factor of cardiovascular disease and premature death. Worldwide, the prevalence of hypertension is increasing at an alarming rate—particularly in China, where 245 million adults currently experience hypertension. Despite significant advances in the treatment and management of hypertension, the percentage of controlled hypertension is still low (<50%) in the adult US population. A nationwide survey conducted from 2012 to 2015 showed that among patients with hypertension in China, 46.9% were aware of their condition, 40.7% took antihypertensive medications, and merely 15.3% had controlled blood pressure (BP) <140/90 mm Hg. Therefore, improving hypertension control is of urgent need and great importance.

A recent systematic review and meta-analysis determined that team-based care was the most effective approach to overcome barriers to BP control. However, this study did not include financial incentive-based trials.
Providing financial incentives is more straightforward and less resource intensive than team-based care, particularly in resource-limited settings. Financial incentives can increase patients’ motivation and help overcome barriers to treatment adherence. Evidence has shown that offering financial incentives may help improve hypertension control. However, the results of current financial incentive-based trials are inconsistent: some trials have yielded negative results, and it is unclear whether providing financial incentives has a sustained effect (eg, >6 months) on hypertension control. On the other hand, the structure and amount of the financial incentive are considered a critical element in the design of these trials since these parameters have varied considerably in different trials. Some studies designed >2 different interventions, such as financial incentives with phone calls or return letters; it is thus not possible to isolate the effects of financial incentives from other components of such an intervention. Furthermore, the effectiveness of financial incentives on BP control may vary according to the racial background and culture. No study has evaluated the effect of financial incentives on hypertension control in China. Despite the wide implementation of evidence-based BP management programs (such as team-based care) in China, the lack and unequal distribution of health care resources contribute to the low hypertension control rate.

Therefore, we designed a 2-arm randomized controlled trial (RCT) to assess the efficacy of financial incentives for BP control among patients with poorly controlled hypertension in China. We hypothesized that financial incentives could reduce BP in patients with poorly controlled hypertension.

What Is New?
This is the first randomized controlled trial in China to examine whether financial incentives for patients were effective in blood pressure control. Details of hypertension management in China were considered when determining the financial incentive amount.

What Is Relevant?
A small financial incentive improved blood pressure control at 3 months of intervention, but a sustained effect (beyond 3 months) was not observed.

Clinical/Pathophysiological implications?
Financial incentives slightly controlled blood pressure in hypertensive patients in the short term. Our findings provide preliminary evidence for the feasibility of using financial incentives in controlling blood pressure in China.

METHODS
The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Study Design
The 2-arm RCT was conducted in 3 cities of the Liaoning province (Shenyang, Dandong, and Fuxin) in China. Details of the study protocol have been published elsewhere. Our analysis followed the CONSORT 2010 recommendations for the analysis of RCT data. This trial was compliant with the 1975 Declaration of Helsinki guidelines and approved by the Shengjing Hospital of China Medical University Medical Ethics Committee (No. 2019PS397K). All the participants or their guardians provided written informed consent.

Participants
Participants with poorly controlled hypertension were selected from 3 hospitals: Shengjing Hospital of China Medical University, Dandong Central Hospital, and Fuxin Mining General Hospital of the Liaoning Health Industry Group. The recruitment period was between September 15, 2019, and January 10, 2020. Inclusion criteria for the participants included (1) participants being aged between 35 and 75 years, (2) the presence of hypertension (BP ≥140/90 mm Hg during 2 separate screening or baseline visits), (3) having WeChat and being able to use it skillfully, (4) staying in their respective city for >12 months, and (5) voluntary participation and provision of written consent to participate in our trial. Exclusion criteria for participants included (1) pregnant women or women who planned to become pregnant within a year, (2) participants with a relocation plan for the coming year, (3) individuals with malignant tumors or severe liver or kidney dysfunction, (4) participants with secondary hypertension, and (5) participants who were unlikely to complete the trial, as judged by a recruiter. Recruiters were uniformly and rigorously trained and had a consistent understanding of the inclusion and exclusion criteria.

Intervention
Participants were randomized to the control and intervention groups in a 1:1 ratio. All participants in the 2 groups received standard WeChat-based education and support for
Table 1. Baseline Characteristics of the Study Population

| Characteristics | Intervention (n=103) | Control (n=104) | P value | Effect size* |
|-----------------|---------------------|----------------|---------|--------------|
| Age, y; mean±SD | 55.2±10.1 | 56.2±10.6 | 0.401 | −0.117 |
| Women, n (%) | 54 (52.4) | 51 (49.5) | 0.676 | −0.029 |
| Currently smoking, n (%) | 27 (26.2) | 34 (32.7) | 0.307 | 0.071 |
| Current drinking, n (%) | 30 (29.4) | 28 (27.2) | 0.723 | −0.025 |
| Physical activity, n (%) | 53 (51.5) | 52 (50.0) | 0.834 | −0.015 |
| BMI, kg/m²; mean±SD | 27.4±4.9 | 27.4±4.6 | 0.987 | −0.006 |
| BP, mm Hg; mean±SD | | | | |
| Systolic | 158.7±14.5 | 159.7±15.4 | 0.647 | −0.064 |
| Diastolic | 93.7±10.6 | 93.9±11.1 | 0.903 | −0.018 |
| No. of steps in Wechat (≥6000), n (%) | 48 (46.6) | 49 (47.2) | 0.725 | 0.028 |
| Use of antihypertensive medications, n (%) | 83 (80.6) | 85 (81.7) | 0.833 | 0.015 |
| Self-reported medication adherence, n (%) | 55 (54.0) | 55 (51.5) | 0.842 | 0.015 |
| Medical history, n (%) | | | | |
| Major CVD | 15 (14.6) | 23 (22.1) | 0.161 | 0.098 |
| Diabetes | 14 (13.6) | 23 (21.9) | 0.110 | 0.111 |
| Hypercholesterolemia | 28 (27.2) | 32 (30.8) | 0.570 | 0.040 |
| TC, mmol/L; mean±SD | 5.1±1.1 | 5.1±1.0 | 0.665 | −0.056 |
| LDL, mmol/L; mean±SD | 3.3±0.9 | 3.2±0.9 | 0.333 | 0.140 |
| HDL, mmol/L; mean±SD | 1.3±0.1 | 1.2±0.3 | 0.415 | 0.118 |
| TG, mmol/L; mean±SD | 2.1±1.5 | 2.5±3.3 | 0.225 | −0.169 |
| GLU, mmol/L; mean±SD | 5.9±2.1 | 6.1±2.3 | 0.576 | −0.081 |
| Uric acid, μmol/L; mean±SD | 339.2±105.1 | 331.2±107.4 | 0.589 | 0.076 |
| Creatinine, μmol/L; mean±SD | 66.0±18.6 | 66.6±19.8 | 0.813 | −0.033 |

BMI indicates body mass index; BP, blood pressure; CVD, cardiovascular disease; GLU, glucose; HDL, high-density lipoprotein; LDL, low-density lipoprotein; TC, total cholesterol; and TG, triglyceride.

*Effect size: Cohen’s d or Phi coefficient.

Randomization and Blinding

Randomization was performed after participants were enrolled. The participants were block-randomized into the intervention and control groups in a 1:1 ratio. Randomization was stratified by geographic region, where the total number of stratifications was three. Computer-generated randomization was concealed and performed with a block size of 4, conducted by a statistician who was not involved in the trial, using SAS, version 9.4 (SAS Institute, Inc, Cary, NC). Due to the behavioral nature of the intervention, participants and principal investigators received and gave financial incentives, respectively; thus, neither were blinded to patient allocation. However, the study staff responsible for measuring the BP and the statistician were blinded to group assignment. The details of the randomization were kept confidential until data analysis was complete.

Procedures

Both groups were administered in-person questionnaires. BP was measured at baseline and at the 1-, 3-, 6-, and 12-month follow-up visit marks. Structured questionnaire items included demographic and lifestyle characteristics and the use of antihypertensive medications and concomitant drugs. Demographic and lifestyle characteristics included sex, age, smoking, alcohol drinking, and physical activity.
Each BP measurement was obtained by study nurses who were masked to group assignment, using a standardized protocol recommended by the American Heart Association. Patients were advised to avoid alcohol, cigarettes, coffee or tea, and exercise at least 30 minutes before BP measurements. After participants rested in the seated position in a quiet room for 5 minutes, trained research personnel measured seated BP from the dominant arm (at the heart level) with an appropriately sized cuff (pediatric, regular adult, large, or thigh). We used a standardized automatic electronic sphygmomanometer (HEM-8102A; Omron, Tokyo, Japan) to eliminate digit preference and minimize interobserver variability. Additionally, for each BP measurement, BP was measured 3× a day for 1 minute, and the mean of the BP values was calculated and used for all subsequent analyses. At the baseline and 12-month follow-up points, BP was measured on 2 consecutive days, and the mean of 6 BP values was used. The participants were asked to report adverse events. If participants experienced excessive BP reduction (systolic BP <100 mm Hg during the day), the study coordinator contacted them to inquire about their health status. In the case of severe adverse events resulting in significant functional impairment or the beginning of radiotherapy, chemotherapy, or surgery, the participant was withdrawn from the study. Removal from the study due to adverse events was evaluated by a cardiologist.

Outcomes

The primary outcome was the net change in systolic BP, defined as the difference in BP between the intervention and control groups, from baseline to the 12-month follow-up period. Since systolic BP has a stronger association with vascular diseases, it was deemed a more reliable measurement than diastolic BP. Secondary outcomes included the net change in diastolic BP, rate of BP control (BP <140/90 mm Hg), and change in self-reported medication adherence. Adverse events included coronary heart disease, stroke, and cardiovascular death.

Statistical Analysis

The sample size calculation was based on the following assumptions: a 7-mm Hg change in systolic BP; an SD of 20 mm Hg in systolic BP at a significance level of 0.05, using a 2-sided test with 90% statistical power; and 20% dropout rate. Thus, a sample size of 200 participants per group was required. All analyses were conducted in accordance with the intention-to-treat principle.

Descriptive statistics for all baseline characteristics were reported for each group. Noncontinuous variables are presented as counts and percentages (%), while continuous variables are presented as mean±SD. Baseline characteristics were compared between the intervention and control groups using an independent sample t test, χ² tests, or Fisher exact tests. Mixed-effects linear regression models were used to compare BP changes between the intervention and control groups. In these models, participants and clinics were assumed to be random effects, while intervention group, time, and interaction were assumed to be fixed effects. Logistic regression analysis was used to analyze categorical outcomes, including hypertension control and medication adherence.

For negative results, we used the concept of a reverse fragility index (RFI) to provide a measure of confidence in the neutrality of results. The RFI was calculated by subtracting nonevents from the group with a lower number of events while simultaneously adding nonevents to the same group to keep the number of participants constant until the Fisher exact test 2-sided P was <0.05.

Statistical significance was set at P<0.05 (2 tailed). Missing data were imputed using a multiple imputation approach. All statistical analyses were performed using SPSS, version 22 (IBM SPSS Statistics for Windows, version 22.0; IBM Corp, Armonk, NY).

RESULTS

The recruitment and retention of research participants are shown in Figure 1. Among the 419 patients initially...
screened, 245 met the BP screening criteria. Of these, 217 patients consented to participate in the study and were enrolled; 109 were randomly allocated to the intervention group and 108 to the control group. Ten participants were lost to follow-up immediately after enrollment and did not attend any visits. Ultimately, 103 individuals in the intervention group and 104 in the control group were included in the analysis. Follow-up rates were 86.5%, 86.9%, 85.5%, and 92.3% for the 1-, 3-, 6-, and 12-month follow-up visits, respectively. After each of the 4 follow-up visits at 1, 3, 6, and 12 months, 51, 76, 66, and 58 participants in the intervention group (respectively) received a ¥50 reward. By the end of the study, the intervention group had received an average of ¥540 for each participant. In the control group, each participant received an average of ¥209. After the 12-month follow-up, no statistically significant differences in baseline BP (158.8±12.3/101.4±7.8 mm Hg versus

Figure 1. Study flowchart.
BP indicates blood pressure.
No significant differences regarding sex, age, baseline BP, medication use, and biochemical measurements were found between the 2 arms of the study (Table 1). Mean baseline BP was 158.7±14.5/93.7±10.6 mm Hg in the intervention group and 159.7±15.4/93.9±11.1 mm Hg in the control group.

As shown in Figure 2, BP in both groups showed a decreasing trend over the 12 months. From baseline to 12-month follow-up, mean systolic BP decreased from 158.7 to 149.5 mm Hg (with a mean decrease of 9.2 mm Hg) in the intervention group and from 159.7 to 149.5 mm Hg (with a mean decrease of 10.5 mm Hg) in the control group.

No significant difference in the change in systolic BP was found between the 2 groups at the 12-month follow-up mark \((P=0.639)\). Conversely, at the 3-month follow-up mark, a significant difference in the change in systolic BP was found between the 2 groups \((-20.9\text{ mm Hg} vs -16.1\text{ mm Hg})\) with a 4.8-mm Hg decrease relative to the control group; \(P=0.018\) [95% CI, -8.8 to -0.8)]. By the 12-month mark, mean diastolic BP decreased from 93.7 mm Hg (baseline) to 86.6 mm Hg in the intervention group and from 93.9 mm Hg (baseline) to 86.3 mm Hg in the control group. Diastolic BP was not significantly different between the groups at any of the 4 follow-up visits \((P>0.05)\) (Table 2).

The rate of BP control was not significantly different between the 2 groups at the 12-month follow-up mark, regardless of covariate adjustment. However, the rate of BP control between the 2 groups varied across visits. The unadjusted BP control rate at the 1-month follow-up mark was 20.2% (18/89) in the control group and 26.7% (24/90) in the intervention group \((P=0.039)\). At 3 months, the BP control rate increased to 33.0% (29/88) in the control group and 48.9% (45/92) in the intervention group. Intervention participants were significantly more likely to achieve a BP <140/90 mm Hg at the 3-month mark \((P=0.030)\). At 6 months, the BP control rate increased to 47.3% (43/91) in the control group and 55.8% (48/86) in the intervention group. However, at 12 months, BP control rates were 15.8% (15/95) in the control group and 20.8% (20/96) in the intervention group. Differences between the groups were no longer significant at the 6- or 12-month marks \((P=0.255\text{ for 6-month and } P=0.368\text{ for 12-month follow-ups}; Table 3)\). Adjusted odds ratios for the intervention group relative to the control group at different time points are presented in Table 3. After controlling for baseline BP, demographic factors, regular smoking and alcohol use, and other medical conditions, no significant difference in BP control rate was observed between the 2 groups across all 4 follow-up visits \((P>0.05)\).

At the 12-month follow-up visit, no significant difference in medication adherence was observed between the control and intervention groups. At all 4 follow-up visits, a significant difference in medication adherence between the intervention and control groups was observed only at the 1-month follow-up mark (adjusted odds ratio, 0.08; \(P=0.025\) [95% CI, 0.009–0.72]).

There were no significant subgroup differences in systolic BP reduction between the 2 groups according to age, sex, body mass index, type of hypertension, and cardiovascular risk \((P>0.05\text{; Figure 3})\).

The RFI in Table 3 shows the robustness of the unadjusted results of BP control rates. At the 12-month follow-up mark, the RFI for hypertension control was 6, indicating that the outcomes of at least 6 control group participants had to change to alter the significance of the results. No participant experienced excessive BP reduction or cardiovascular-related death, and a total of...
5 people had a stroke—3 in the intervention group and 2 in the control group. No other adverse events were reported. None of the participants withdrew from the study because of adverse events.

**DISCUSSION**

To address the challenging issue of hypertension control, we conducted a randomized trial using a behavioral economics theory-based intervention. BP decreased in both the control and intervention groups, with an average systolic BP reduction of 12 mm Hg. Financial incentives were statistically effective for the net decrease in systolic BP and the rate of BP control, but this effect was observed only in the early stage (at the 3-month follow-up mark). This effect was not observed at the 1-, 6-, and 12-month follow-up marks.

Financial incentives are proven to induce changes in health-related behavior, such as smoking cessation, weight loss, glycemic control, and hypertension control, thereby aiding in disease management.11,14,16,17,24,25 Nevertheless, providing financial incentives to patients with hypertension is not always effective. Kaboli et al11 used 3 interventions to encourage patients to talk to their doctors about antihypertensive medication intensification. To prompt patients, one group received a letter; the second group received a letter and a financial incentive; and the third group received a letter, a financial incentive, and a telephone call. After 12 months, improved BP control was evident only in the group receiving all 3 interventions. Shapiro et al14 offered intervention participants a combination of fixed payments, contingent payments, and lotteries (eg, payment per mm Hg of improved BP, or a lottery card, to meet the health goals set by the researchers) in a highly disadvantaged minority population. This study revealed that financial incentives for measuring home BP aid in achieving short-term improvement in systolic BP control. However, this effect was

**Table 3. Unadjusted and Adjusted Results of Hypertension Control at Follow-Up**

| Month measured | Intervention | Control | P value | RFI | Adjusted odds ratio* | 95% CI | P value |
|----------------|-------------|---------|---------|-----|---------------------|-------|---------|
| 1              | 24/90 (26.7) | 18/89 (20.2) | 0.309 | 5  | 1.446              | 0.683–3.061| 0.336   |
| 3              | 45/92 (48.9) | 29/88 (33.0) | 0.03  | NA | 1.738              | 0.884–3.418| 0.109   |
| 6              | 48/86 (55.8) | 43/91 (47.3) | 0.255 | 6  | 1.453              | 0.735–2.873| 0.283   |
| 12             | 20/96 (20.8) | 15/95 (15.8) | 0.368 | 6  | 1.527              | 0.665–3.509| 0.318   |

NA indicates not applicable; and RFI, reverse fragility index.
*Logistic regression models controlling for baseline BP, demographic factors, smoking and alcohol use, and other medical conditions.

**Figure 3. Difference in systolic blood pressure changes among patients with hypertension, by subgroup.**

Abbreviation: BMI, body mass index; IDH, isolated diastolic hypertension; ISH, isolated systolic hypertension; SDH, systolic and diastolic hypertension; NA, not applicable.
*cardiovascular risk includes the history of major cardiovascular disease, hypercholesterolemia, and diabetes.
only observed during the 6 months of the intervention but was not sustained after incentives were withdrawn. In another trial conducted among New York State Medicaid managed care patients, financial incentives had a negligible impact on BP control regardless of whether the participants were delivered process incentives, outcome incentives, or a combination of the two. In our trial (which was the first RCT in China to assess the effect of financial incentives on BP control), financial incentives were effective in the short term, but the effect was not sustained in the long term. Therefore, the effect of financial incentives likely differs substantially based on the structure of the incentives, the population involved, and the study design.

In our trial, the lack of a sustained effect of financial incentives on BP control may be a result of various reasons. First, the amount and structure of our incentive payments may not have been attractive enough to participants, despite our payments being sufficient to cover 1 year of health insurance premiums and antihypertensive drug use. Our incentives were not substantial compared with the amount of the incentive payments in another study (where this study yielded positive results, using incentives that averaged >8% of annual income). Future research should increase the amount of the financial incentives to obtain a more sustained effect on BP control. Second, the immediacy of financial incentives, also known as present bias in economics, may also have influenced the sustainability of this intervention on BP control. Participants were likely to focus on the treatment in the initial phase but were prone to burnout during long term, sustained focus on treatment. Thus, the effect of financial incentives may be more pronounced in the early stages of a trial. Third, after participants had received the intervention for 3 months, the COVID-19 pandemic began in China. Participants may have focused more on COVID-19 prevention and thus neglected BP control as a result. Fourth, the absence of noticeable effects in systolic BP, even if complete recruitment was achieved. The null findings of this trial might be attributed to insufficient statistical power regarding the detection of a significant difference in primary outcomes. However, given the minimal difference in systolic BP by the end of the intervention between the 2 groups, it is unlikely that financial incentives provided a significant benefit in reducing systolic BP, even if complete recruitment was achieved. Second, nearly all prepandemic cardiology-related clinical trials were put on hold during the pandemic. These obstacles disrupted the recruitment of participants. Ultimately, 207 (52%) of the original 400 participants were recruited. Based on an actual sample size of 207, with all other assumptions remaining the same, the recalculated statistical power was 71%. Therefore, we cannot rule out that the null findings of this trial might be attributed to insufficient statistical power regarding the detection of a significant difference in primary outcomes. However, given the minimal difference in systolic BP by the end of the intervention between the 2 groups, it is unlikely that financial incentives provided a significant benefit in reducing systolic BP, even if complete recruitment was achieved. Second, nearly all prepandemic cardiology-related clinical trials were put on hold during the pandemic. Thus, we used remote BP monitoring at the 3- and 6-month follow-ups. BP measurements were taken through live video calls, and trained research staff guided the participants to measure BP correctly at home, based on standard protocol. Third, China is geographically, culturally, and socioeconomically diverse; thus, generalizing the findings of this study to other Chinese populations must be performed with caution.

Conclusions

Based on this RCT conducted in a Chinese population, a small financial incentive improved BP control at 3 months of intervention, but a sustained effect of BP control (beyond 3 months) was not observed. Future studies that focus on identifying the appropriate
amount and structure of financial incentives for BP control are warranted.

**Perspectives**

This RCT, conducted in a Chinese population, demonstrated that financial incentives could slightly control BP in hypertensive patients in the short term; however, the effects of financial incentives on BP control were not sustainable. Our findings provide initial evidence of the feasibility and potential of financial incentives for hypertension management in China. Details regarding hypertension management in China were considered when determining the amount of the financial incentives in our trial. Future studies that focus on identifying a more appropriate amount and structure of financial incentives for BP control are warranted.

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