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The effect of text messaging intervention on lowering modifiable risk factors for cardiovascular diseases, Riyadh, Saudi Arabia

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Abstract
Objective: To determine whether SMS reduces modifiable cardiovascular risk factors.
Methods: From February to July 2018, the authors performed an RCT on primary care patients at King Khaled University Hospital (KKUH). The patients completed a questionnaire with personal data, and E-SEHI was used to evaluate their low-density lipoprotein (LDL), glycated hemoglobin (HBA1C), systolic blood pressure (SBP), diastolic blood pressure (DBP), Body Mass Index (BMI), and smoking status at baseline and 6-month later. Then After six months, the intervention group received four weekly SMS motivating messages that urged them to exercise frequently, quit smoking, eat well, and stick to medications, whereas the control group did not get SMS intervention.
Results: Five hundred forty-five participants participated in this study. The intervention group included 202 (37.1%) persons, while the control group had 343 (62.9%). Comparable age and gender distributions were seen in the intervention and control groups.
Total cholesterol and LDL dropped in the intervention group. Control group HBA1c and FBS levels improved.
SBP and DBP decreased in both intervention and control groups. However, the intervention group's DBP decreased more than the control groups, whereas the control group's SBP decreased less.
Those aged 36-60, men, and those with less than a high school degree had lower HBA1c values (p 0.05). Furthermore, the control group decreased more than the intervention group.
The intervention group's 36-60-year-olds with less than a high school education lowered their total cholesterol and LDL levels more (p 0.05).
DBP in the intervention group decreased across both sexes and low-educated adults (p 0.05).
Conclusion: Text messaging has been demonstrated to be a helpful and cost-effective way to modify cardiovascular risk factors. To enhance effectiveness considerably, we advocate delivering patients' interventional massages, which are well designed, interactive audiovisual, automated, focused, and personalized, more frequently and for a longer period.

Keywords: Text messaging intervention, modifiable cardiovascular risk factors, Saudi Arabia

Introduction
Cardiovascular Diseases (CVD) are a major health problem worldwide and responsible for high rates of death and disability in developed countries such as the United States and Europe [1]. In Saudi Arabia, the profile is similar to the global situation, demonstrating that CVDs are the leading cause of death [1-2].
While the non-communicable disease (NCD) burden in the Gulf Cooperation Council (GCC) countries, including Saudi Arabia, has surged over the past decades, with the consequent social and economic burden. The large NCD burden indicates the need to comprehensively address the main risk factors contributing to NCDs [2].
CVDs refers to cardiovascular disorders in general and atherosclerosis or arterial diseases. CVD raises mortality and disability rates in developed nations like the U.S. and Europe [1]. For example, CHD, a subtype of CVD, causes 385,000 deaths yearly in the U.S. and costs more than $109 billion [3, 4].
Health care has improved through text messaging. It is low-cost, widely used, does not need an expert, and applies to many health behaviors and conditions. Text messages may be sent at any time. Also, messages are delivered whether the phone is on or off [3].

Nowadays, text messaging in health care systems includes appointment and medication reminders, preventive health, population awareness, illness education, procedures, diseases, and pain management [5].

Hypertension, smoking, hyperlipidemia, diabetes mellitus, physical inactivity, overweight, and dietary habits are considered modifiable risk factors for cardiovascular diseases [6, 7]. Numerous studies show that lowering blood pressure reduces this risk [8, 9]. A recent assessment on the efficacy of lifestyle-focused text messaging on risk factor reduction in patients with coronary heart disease found that the intervention group's 6-month systolic blood pressure was lower than the control group's [10]. In addition, a single-blind randomized study using mobile phone text messages to improve adherence to therapy in individuals with high blood pressure demonstrated a slight drop in systemic blood pressure in the intervention group compared to the control group [11].

Although hypertension is the most significant risk factor for cardiovascular disease [6, 7], diabetic individuals with cardiac disease have a poorer prognosis than others [12, 13]. Text messaging had improved HBA1C levels compared to the control group [14]. Text messaging for five months in the U.S. lowered HBA1C from 7.9% to 7.2%, with no change in the control group [15]. Similarly, the intervention group that got two daily text messages for six months showed a 1.05 percent decline in HBA1c vs. a 0.60 percent drop in the control group [16].

High LDL is another cardiovascular disease predictor [17]. Therefore, reducing LDL levels has been recognized to reduce the risk. Also, texting the patient decreased LDL [11].

Overweight people are at higher risk for heart disease, stroke, and type 2 diabetes [18, 19]. Many interventions are attempted to lower BMI, and text messaging has been approved as effective (10, 20, 21). Research indicated that after 18 months, patients had substantially reduced mean weight (-4.2 kg [95% CI -6.0 to -2.4] [21].

Bad dietary habits, especially excessive fat and salt consumption, may lead to cardiovascular disease [22]. Text messaging helped reduce this potential harm. Participants have replaced sugary beverages with water, desserts with fruit, fries with a salad, and grilled meals instead of fried [23]. Also, 12-week SMS messaging improved diet behavior in obese young people [24]. Lastly, six patients with acute compensated heart failure (ADHF) with a mean of 22% ejection fraction were engaged in text messaging intervention; 66% of participants claimed text messages lowered salt consumption [25].

The effort for health promotion to modify the cardiovascular disease risk factors is badly needed all over the world to reduce morbidity and mortality. For example, Saudi Arabia focuses on health promotion as part of the Saudi vision 2030 [24].

The infrastructure in Saudi Arabia is well established for online communication with patients or people in general. According to the General Authority of Statistics, the internet and mobile phone are widely used among Saudis, with family access to Smartphones reaching 92.33% and internet access reaching 89.77% in 2018.

To the best of our knowledge, no research has been found that measures the effect of health promotion SMS texting in modifying CVD risk factors.

We hypothesized that text messaging intervention for six months would improve the modifiable risk factors (LDL, B.P., HBA1C, BMI) in cardiovascular patients in Riyadh. The current study aimed to determine whether SMS text messaging to patients reduces modifiable cardiovascular risk factors.

Methods

1. This study is a randomized interventional control, and a single-blind trial carried out in Primary care clinics, king Khaled university hospital (KKUH). Patients in the waiting area were targeted from February to July 2018.
2. The Participants included male and female patients 18 years old and above with one or more risk factors of cardiovascular diseases (High LDL, High B.P., high BMI, High HBA1C, Smoker) and has a personal mobile phone.
3. This study had 80% power at type 1 error of 5%, 2 tailed to detect a difference of 10 mg\dl of LDL level, assuming the mean LDL level of the control group is 111.3 mg\dl, ± 40.3. [29] The sample increased by 50 patients to allow for a 10% loss of follow-up we recruited 560 patients, with 255 completed patients for each group.
4. Any patients attending the primary care clinic with previous inclusion criteria were included. The institutional review board of the College of Medicine, King Saud University, approved the project proposal prior to the initiation of the study (Research project No. E-17-2374).
5. All participants received a written consent form and were informed about the purpose of the research, why they were chosen, and all potential risks and benefits, and they could withdraw from the study at any time.
6. After signing the consent form, they completed a form that contained personal data, then excel randomized the patients into intervention or control groups based on age and sex.
7. The intervention group was text messaged using short message services (SMS). The intervention group received four weekly messages containing health education about the cardiovascular risk factors and motivating them to do a healthy habits. The topics covered were brisk walking daily, eating fruits and vegetables, adherence to medications and smoking cessation. The messages were in friendly motivational mode, for example:
   (Good morning #name, do not forget to take your medication for today! Have a nice day) (Do you know that walking 30 minutes at least five days a week will help protect your heart?)
8. Instead of having a dessert at night, try to have fruit in the evening for today
9. The participants were interviewed by data collectors using the questionnaire, which contained two parts. The first part consisted of personal data such as age, sex, marital and educational status, smoking status, and mobile number. The second part contained the clinical data obtained from E-Sehi at the beginning of the study and after six months of intervention, which will contain the measurements of (LDL, BP, HBA1c, weight, and height to calculate the BMI).
10. The primary endpoint was the LDL level change, whereas the secondary endpoint was the decreased level in B.P., HBA1C, BMI, and smoking cessation.

Pilot study

Prior to the main study, the author conducted a pilot study with the questionnaire on 20 women to check the applicability and clarity and to identify any difficulties with the questionnaire; the pilot study was also employed to ensure the cultural and scientific appropriateness of the instrument for the Saudi community, as well as to estimate the time needed to fill out the questionnaire. The questionnaires take approximately 15-20 min to fill out. The questionnaire was modified according to the pilot study's results. Patients who participated in the pilot study were excluded from the main study.

Data analysis

Data were analyzed using IBM SPSS Statistical software for Windows version 26.0 (IBM Corp., Armonk, N.Y., USA). Descriptive statistics (frequencies, percentages, mean and standard deviation) were described as the categorical and quantitative variables. Bivariate analysis was carried out using a student's t-test for independent samples, a one-way analysis of variance followed by a posthoc test for quantitative outcome variables to compare the mean differences values in relation to the categorical study variables have two and more than two options. Odds ratios were used to measure the association between two categorical variables. A *p*-value of $\leq$ 0.05 and 95% confidence intervals reported the statistical significance and precision of the results.

Results

According to Table 1, this research included a total of 545 patients. There were 202 people in the intervention group, which is 37.1 percent of the total, and 343 people in the control group (62.9 percent). The intervention and control groups had comparable age and gender distributions, and statistical analysis did not reveal any significant differences between the two.

In the intervention group, there was a noticeable decrease in the total cholesterol and LDL level, as seen in Figure 1. On the other hand, the HBA1c and FBS levels showed some improvement in the control group. Figure 2 demonstrated a statistically significant decrease in both SBP and DBP in both the intervention and the control groups. However, this decrease occurred more in the DBP of the intervention group than it did in the control group, while the SBP of the control group was lower than that of the intervention group.

Table 2 compares the mean differences in BMI and HBA1c between the intervention and control groups based on their characteristics.

The BMI differences between the intervention and control groups were not statistically significant across any of the surveyed demographic characteristics. However, regarding HBA1c, there was some statistically significant drop in the level among individuals of middle age, males, and those with below high school levels of education. Despite this, the declines were larger in the control group than in the intervention group.

Table 3 compares the mean differences in total cholesterol and LDL between the intervention group and the control group based on the characteristics of the two groups. Patients in the middle age range with an education level of less than a high school managed to lower their total cholesterol and LDL levels more effectively in the intervention group compared to the control group (p 0.05). On the other hand, no decrease could be considered statistically significant in the mean differences in total cholesterol and LDL levels between the intervention group and the control group in either gender.

Table 4 compares the mean differences between SBP and DBP based on the characteristics of the intervention group with those of the control group.

There was a statistically significant decrease in DBP among both sexes and individuals with less than a high school education in the intervention group.

On the other hand, there was no significant difference in blood pressure between the intervention and control groups for SBP across all demographic variables investigated.

Discussion:

This study is the first attempt to conduct a clinical trial in the Saudi community using health promotion SMS texting messages interventions to modify the CVD risk factors. The effort for health promotion to modify the Cardiovascular Disease risk factors is badly needed all over the world to reduce morbidity and mortality. Moreover, in Saudi Arabia, the “vision 2030” focuses on health promotion and disease prevention.

Cardiovascular Disease (CVD) is a major health problem worldwide. CVD refers to any disorder in the cardiovascular system in general, specifically those related to atherosclerosis or arterial diseases. CVD is responsible for height rates of death and disability in developed countries such as the United States and Europe [1]. For example, Coronary Heart disease (CHD), a subset of CVD, is the cause of 385000 deaths annually in the United States alone, costing health care more than $109 billion [2].

According to World Health Organization reports (WHO), The profile 2014 demonstrated that CVD is responsible for 46% of non-communicable disease deaths in the Kingdom of Saudi Arabia (KSA) [2]. Furthermore, local studies have shown that CHD represents the third most common cause of hospital-based mortality in KSA due to late detections and diagnosis. Thus, studies have suggested that it is necessary as a preventive measure to modify controlled risk factors such as diet, exercise, and avoidance of smoking, in addition to periodically checking up to prevent advanced and progressive stages of CVD [1].

Text messaging has been used as a tool for health care improvement. It is available on every mobile phone, has low cost, is widely used, does not require an expert to use, and is widely applicable to various health behaviors and conditions. Text messaging also can be accessed at any time, which is personally convenient. Furthermore, it is time-independent; messages will be delivered whether the phone is on or off [3].

Nowadays, text messaging in health care systems can be split into appointment and medication reminders, preventative health, population awareness, disease education, conditions, procedures, and pain management [4].

The infrastructure is well established for online communication with patients or people in general. Also, the internet and mobile phone are widely in use among Saudis.

Modifiable risk factors in cardiovascular diseases are hypertension, hyperlipidemia, diabetes mellitus, physical inactivity, overweight, smoking, and diet behaviors [6].

High blood pressure is considered the most important single risk factor for the development of cardiovascular diseases [8]. Fortunately, numerous studies suggest that controlling blood pressure would reduce this risk [8, 9].

The current study demonstrated a statistically significant decrease in SBP and DBP in both the intervention and the control groups. However, this decrease occurred more in the DBP of the intervention group than it did in the control group, while the SBP of the control group was lower than that of the intervention group.

There was a statistically significant decrease in DBP among both sexes and individuals with less than a high school education in the intervention group (p<0.05). This finding is similar to a previous review on the effect of lifestyle-focused text messaging on risk factor modification in patients with coronary heart disease. They concluded that the blood pressure at 6-month follow-up was significantly lower in the intervention group compared with the control group [10]. In addition, a focused single-blind randomized trial of mobile phone text messages was done to support adherence to treatment in adults with high blood pressure consisting of 1372 participants found a small reduction in systemic blood pressure in the intervention group compared with the control group [11].

Although hypertension is the most important risk factor for cardiovascular disease [11], diabetic patients who develop cardiac diseases experiment a worse prognosis than other factors [12, 13].

There was a noticeable decrease in the total cholesterol and LDL level In the intervention group. Patients in the age range 36-60 with an education level of less than a high school managed to lower their total cholesterol and LDL levels more effectively in the intervention group compared to the control group (p 0.05). On the other hand, no decrease could be considered statistically significant in the mean differences in total cholesterol and LDL levels between the intervention group and the control group in either gender.

LDL is another major predictable cause of cardiovascular diseases [17]. Luckily, reducing LDL to an optimal level has been approved to prevent the risk. The present study showed that in the intervention group, there was a noticeable decrease in the total cholesterol and LDL level. Despite this, the declines were larger in the control group than in the intervention group.

Patients in the age range (36-60) with an education level of less than a high school managed to lower their total cholesterol and LDL levels more effectively in the intervention group compared to the control group (p< 0.05). This finding is similar to a previous study where text messaging to the patient significantly lowered LDL [10].

On the other hand, the HBA1c and FBS levels showed some improvement in the control group. The HBA1c decreased among individuals aged (36-60), males, and those with below high school levels of education (p<0.05). This finding may be due to patients in both groups exchanging the SMS messages. Past studies demonstrated that mobile text messaging had improved the level of HBA1C significantly compared to the control group [14-16].

Overweight and obesity are major public health concerns worldwide, as overweight individuals are at greatly increased risk for heart disease, stroke, and type 2 diabetes [19, 20]. Our study did not show statistically significant BMI differences between the intervention and control groups across any of the surveyed demographic characteristics. This finding is contrary to many text messaging interventions which found a reduction in the BMI [10, 19, 21, 22]. This discrepancy may be due to the short intervention period, the need for more frequent massage, the design of the SMS messages, and not forgetting the individual attitude toward losing weight.

However, in the SMS messages, we focused on lowering fat and sodium intake and increasing fruit and vegetable consumption, which could affect the cardiovascular system [22]. We also advised our participants to replace sugary drinks with water, and fruit instead of dessert, exchange fries with a salad, and eat grilled food instead of fried. This advice was shown in other studies to have changed participants' diet behaviors and modified the cardiovascular diseases risk toward the better [23-25].

Limitation of the study

The study was conducted in a single center in Riyadh, the capital and the largest city in Saudi Arabia. The results may not necessarily be generalizable to the other regions. Different regions of the country have unique traditions, cultures, and beliefs. Adopting a multi-center, multi-city approach in future studies may better be representative of the population. Lastly, although an anonymous self-administered questionnaire was used in collecting the data, which allowed the participants to respond freely, people were not used for such targeted health promotion materials, and a tendency to agree or disagree with some questions such as smoking due to fear of judgment may introduce some bias. Due to lack of funding, we designed the intervention to depend on SMS text messages which some of the participants may not favor

Conclusion

Cornerstone to restricting serious complications. Text messaging intervention has shown some advantages and cost-effectiveness in achieving this modification. So we recommend that future research try sending patients messages using interactive audiovisual materials. These interventional messages may result in great benefits for risk factor modification, particularly if automated, focused, and tailored more frequently and for longer. Also, recruiting expert designers to improve the artistic presentation

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- Author Contributions:
- All authors contributed to the study's conception, design, and approval of the final manuscript for publication. AA, AA, LA, HB, AA: Data collection, interpretation of data. SA: Data analysis, supervision of work, writing, and editing of the manuscript.
- Funding: This study has not received any external funding.

Conflicts of interest

The authors declare that there are no conflicts of interest.

Table 1: Comparing the age and sex variables of intervention and control groups

Characteristics	Frequency (%) 545[100.0]	Intervention (%) 202[37.1]	Control (%) 343[62.9]	p-value
Age				0.72
≤35	72(13.2)	29(14.4)	43(12.5)	
36-60	248(45.5)	88(43.6)	160(46.6)	
61+	225(41.3)	85(42.1)	140(40.8)	
Gender				0.78
Male	274(50.3)	100(49.5)	174(50.7)	
Female	271(49.7)	102(50.5)	169(49.3)	

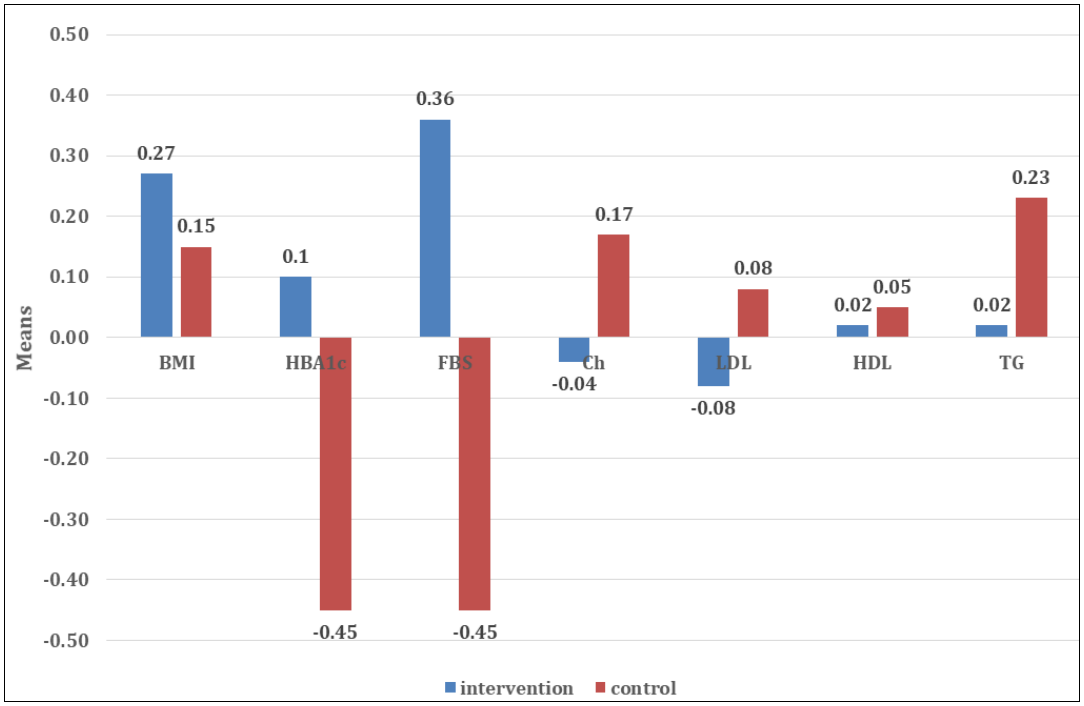

Fig 1: Effect of intervention on some variables

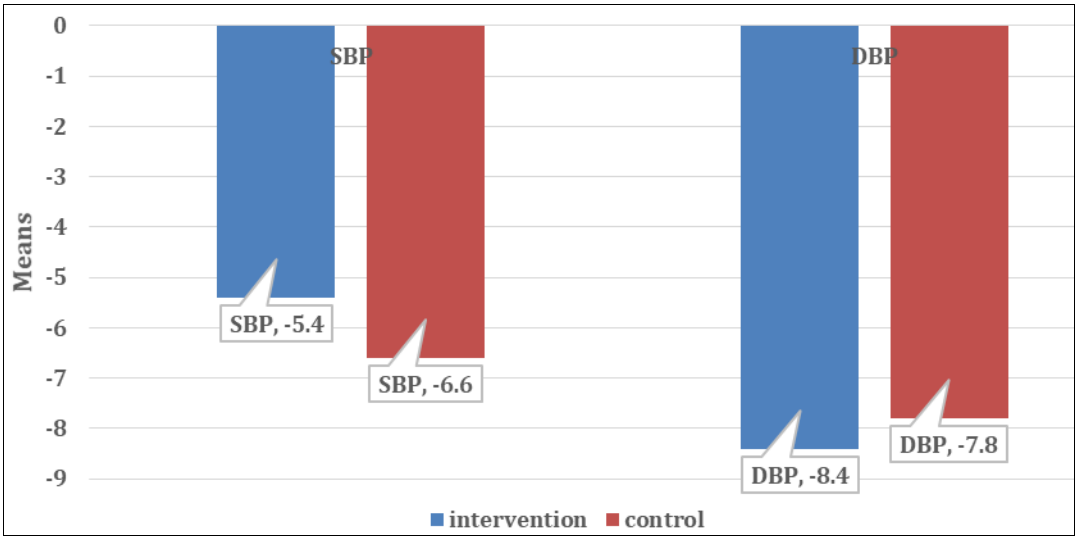

Fig 2: Effect of intervention on SBP and DBP variables

Table 2: Comparing the means differences of BMI and HBA1c by the characteristics of the intervention and control groups.

Characteristics	Mean differences Intervention Control	p-value	Mean Difference (95% Confidence Interval of the Difference)
Means differences of BMI			
Age			
≤35	[13]-0.54(1.80) [18]-0.33(1.71)	0.74	-0.2075(-1.5148-1.0998)
36-60	[52]0.15(1.52) [72]0.23(1.88)	0.78	-0.0889(-0.7172-0.5393)
61+	[40]0.69(2.14). [64]0.20(3.22)	0.39	0.4897(-6530-1.6325)
Gender			
Male	[47] 0.43(2.21) [78] 0.25(2.65)	0.69	0.1841(-0.7307-1.0990)

Female	[58] 0.13(1.47) [76] 0.05(2.25)	0.82	0.0784(-6197-0.7765)
Educational level			
Less than high school	[44] 0.43(1.20) [91] 0.12(2.01)	0.09	0.5589(-0.0933-1.2112)
High school and above	[61] 0.15(2.19). [63] 0.56(3.05)	0.39	-0.4119(-1.3595-0.5357)
Means differences of HBA1c			
Age			
≤35	[17] 0.32(1.52) [16] -0.19(1.44)	0.32	0.5231(-0.5322-1.5785)
36-60	[60] 0.22(1.21) [76] -0.39 (1.81)	0.01	0.6177(0.1292-1.1062)
61+	[56]-0.09(0.95). [68] -0.59(3.22)	0.08	0.4992(-0.0617-1.0602)
Gender			
Male	[72] 0.05(1.19) [87] -0.80(2.03)	.002	0.8689(0.3319-1.4058)
Female	[61] 0.15(1.12) [73] -0.03(1.13)	0.31	0.1960(-0.1917-0.5837)
Educational level			
Less than high school	[55] -0.05(0.80) [92] -0.59(2.01)	0.05	0.5458(-0.0166-1.1082)
High school and above	[78] 0.21(1.35) [68] -0.26(1.21)	0.02	0.4830(0.0605-0.9054)

Table 3: Compared the means differences of total cholesterol and LDL by the characteristics of the intervention and control groups.

Characteristics	Mean differences Intervention control	p-value	Std. Error Difference (95% Confidence Interval of the Difference)
Means differences of total cholesterol			
Age			
≤35	[14] 0.39(0.58) [17] 0.09(0.80)	0.25	0.2997(-0.2247-0.8241)
36-60	[53] -0.17(0.92) [63] 0.30(0.94)	0.007	-0.14803(-0.8275- -0.1330)
61+	[41] 0.01(1.00) [51] 0.04(0.82)	0.83	-0.0392(-0.4182-0.3397)
Gender			
Male	[55] 0.00(0.95) [72] 0.23(0.83)	0.15	-0.2269(-0.5407-0.0868)
Female	[53] -0.07(0.92) [59] 0.10(0.95)	0.31	-0.1801(-0.5322-0.1719)
Educational level			
Less than high school	[43] -0.24(1.01) [73] 0.17(0.89)	0.02	-0.4199(-0.7772- -0.0626)
High school and above	[65] 0.10(0.85) [58] 0.17(0.88)	0.66	-0.0685(-0.3807-0.2437)
Means differences of LDL			
Age			
≤35	[14] 0.11(0.59) [17]0.08(0.76)	0.91	0.2761(-0.4842-0.5394)
36-60	[53] -0.19(0.85) [61]0.18(0.83)	0.02	-0.3680(-0.6810- -0.0549)
61+	[41] 0.00(0.89) [49]-0.02(0.70)	0.86	0.0285(-0.3063-0.3633)
Gender			
Male	[55] -0.07(0.85) [70] 0.14(0.73)	0.12	-0.2239(-0.5070-0.0591)
Female	[53] -0.07(0.92) [57] 0.10(0.82)	0.56	-0.0916(-0.4037-0.2205)
Educational level			
Less than high school	[43] -0.18(0.89) [71] 0.09(0.75)	0.07	-0.2822(-0.5931- -0.0285)
High school and above	[65] -0.00(0.80) [56] 0.08(0.81)	0.57	-0.3733(-0.3807-0.2069)

Table 4: Compared the means differences of SBP and DBP by the characteristics of the intervention and control groups.

Characteristics	Mean differences Intervention control	p-value	Std. Error Difference (95% Confidence Interval of the Difference)
Means differences of SBP			
Age			
≤35	[17] -1.29(17.54) [21]-9.14(13.08)	0.12	7.8487(-2.2296-17.9271)
36-60	[66] -5.53(16.60) [89]-4.17(15.88)	0.60	-1.3505(-6.5480-3.8469)
61+	[58] -6.55(14.23) [80]-8.52(15.03)	0.43	1.9732(-3.0428-6.9893)
Gender			
Male	[73] -5.12(14.92) [103]-6.20(13.89)	0.62	1.0806(-3.2466-5.4078)
Female	[68] -5.78(16.71) [87]-6.97(16.95)	0.66	1.1976(-4.1910-6.5862)
Educational level			
Less than high school	[58] -6.81(17.18) [110] -6.54(16.74)	0.92	-0.2649(-5.6782-5.1485)
High school and above	[83] -4.48(14.71) [80]-6.57(13.26)	0.34	2.0930(-2.2447-6.4308)
Means differnces of DBP			
Age			
≤35	[17] -7.88(13.06) [21] 8.85(12.50)	0.81	0.9747(-7.4659-9.4155)
36-60	[66] -8.33(12.21) [88] -8.39(10.80)	0.97	0.0530(-3.6242-3.7303)
61+	[58] -8.58(11.48) [80] -6.81(11.38)	0.37	-1.7737(-5.6699-2.1225)
Gender			
Male	[73] -6.35(10.87) [103] -9.67(10.50)	0.04	3.3234(0.1057-6.5411)
Female	[68] -10.55(12.71) [86] -5.48(11.66)	0.01	-5.0704(-8.9628--1.1780)
Educational level			
Less than high school	[58] -10.08(12.84) [109] -6.46(11.88)	0.07	-3.6183(-7.5420-0.3054)
High school and above	[83] -7.19(11.19) [80]-9.55(10.02)	0.15	2.3572(-0.9338-5.6482)

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