The application effect of internet technology on managing patients with hypertension in a medical center
A prospective case–control study
Bai-Ding Yin, BS\textsuperscript{a}, Da-Hong Tu, MD\textsuperscript{b}, Nuo Yang, MD\textsuperscript{d}, Jing Wang, BS\textsuperscript{c,∗}

Abstract

Objectives: This study aimed to investigate the application effect of internet technology for managing patients with hypertension in a medical center.

Methods: From December 2017 to December 2018, 400 patients with hypertension in two community health service stations affiliated to Beijing Shijitan Hospital (China) were enrolled in the present study. According to the alternating method, these patients were divided into a control group (routine medical hypertension management) and an e-intervention group (internet technical secondary hypertension management). Blood pressure levels after intervention in both groups, as well as blood pressure control, medication compliance, active health behaviors, and two-way referral rate were observed.

Results: Following the interventions, blood pressure levels were significantly lower in the e-intervention group compared with the control group, and the proportion of good blood pressure control, medication compliance, active health behavior, and two-way referral were all significantly higher compared with the control group.

Conclusion: The application of internet technology in medical associations may help to decrease patients’ blood pressure and improve the effective management of middle-aged and older patients with hypertension in communities.

Abbreviations: APP = application, DBP = diastolic blood pressure, SBP = systolic blood pressure.

Keywords: application effect, high blood pressure, internet platform technology, medical consortium, two-way referral

1. Introduction

The Report on Nutrition and Chronic Diseases of Chinese Residents (2015) revealed that in 2012, the prevalence of hypertension was 25.2% among adults 18 years and older and that chronic non-infectious diseases, such as hypertension and coronary heart disease, have become the primary threats to the health of Chinese residents.\textsuperscript{1–4} The creation of a collaborative service model in a medical setting is an approach for realizing hierarchical diagnosis and treatment. It is a method through which the institutional innovation of medical and health systems can be developed, which is conducive to improving the allocation and utilization efficiency of limited medical and health resources and improving the service capacity of the basic level and overall efficiency of the service system. Medical resource information-sharing relies on information platform construction, helps to ensure the continuity of medical services within medical institutions, and guides patients to seek medical treatment in an orderly manner, thereby improving the effective utilization of medical resources. Adopting the use of internet technology in medical institutions can help to better realize the bottom-to-top linking of medical resources, support efficient collaboration of business, and can be conducive to the development of two-way referrals and other services.

The application of internet technology in a medical setting was evaluated in this paper to assess its effect on the management of patients with hypertension in Beijing Shijitan Hospital (China), and to provide evidence for supporting its application in the management of chronic diseases, such as hypertension.

2. Materials and methods
2.1. Study subjects

The present study was a prospective case-control study. From December 2017 to December 2018, middle-aged and older patients with hypertension, who visited two community health...
service stations in Beijing Shijitan Hospital, were enrolled in the present study. According to the alternating method, the patients were divided into two groups, that is, an e-intervention and a control group. The duration of follow-up was 12 months. The ethics committee of our hospital approved the present study, and all patients provided signed informed consent for inclusion in the study.

Communication using the WeChat application is common in China. The “kangkang shengshi” WeChat public account was established to include patients using the application on their mobile phone in the “hypertension management group.” General practitioners regularly publish knowledge on the occurrence and prevention of hypertension in this WeChat group through the provision of a daily article. This content includes text, charts, and videos about hypertension. The WeChat group members were encouraged to actively communicate, exchange feelings, and encourage mutual supervision among one another. Each patient was asked to report whether or not they were using any medication, the frequency of doing so, as well as their diastolic blood pressure (DBP) and systolic blood pressure (SBP) in the WeChat group before 8:00 pm daily. The list of foods conducive to the control of blood pressure was prepared in table form and uploaded to the group to allow patients to gain a better understanding of the impact of a reasonable diet and a healthy lifestyle on blood pressure.

### 2.2. Inclusion and exclusion criteria

**Inclusion criteria:**

1. patients who had been definitively diagnosed with hypertension;
2. patients with an education level of primary school or above;
3. patients aged 45 years and older.

**Exclusion criteria:**

1. patients with atypical understanding ability and patients who were unable to cooperate with the study requirements;
2. patients with severe heart, liver, kidney, or other leading organ dysfunctions;
3. women who were pregnant or lactating.

### 2.3. Management plan

In the control group, patients received routine hypertension management in the medical center. All community residents had established health records and signed contracts with family doctors. The health information of these residents was collected through physical examination, community medical treatment, and health management. The medical center had expert clinics established in the community and regularly carried out health consultations and patient education activities. These primarily included blood pressure monitoring, recording, and self-management as approaches for better patient management, designing individualized treatment, and identifying more patients with hypertension, and ensuring their management. The question-and-answer format for medication inquiries was used in the present study. Patients took antihypertensive medication in the morning, and the dosage remained the same for the entire study period. Blood pressure was measured in the morning and before breakfast, lunch, and dinner. Patients rested quietly for 10 min in a seated position when measuring their blood pressure in the right upper extremity, and the average was taken from measurements taken prior to the three meals noted above. All BP values were obtained from patients via WeChat. Patients sent their BP values at least five times a month via WeChat. The 200 patients in the e-intervention group were contacted via WeChat, and the 200 patients in the control group were contacted only through the outpatient clinic.

Only the patient and the doctor in charge were able to record and view the results, and all information was kept strictly confidential. The exported data also could not be exported with the patient’s name or contact information to prevent the leaking of patient information and protect patients’ privacy.

### 2.4. Observation indexes

The primary outcome was patients’ BP levels before and after management. Other outcomes included good control of hypertension, medication compliance, active health behavior, and two-way referral.

At present, the standard indicating a high BP in China is 140/90 mmHg; therefore, good control of hypertension was defined as SBP of <140 mmHg and a DBP of <90 mmHg. These values followed recommendations in Chinese hypertension guidelines.\(^5\)

Blood pressure was measured using a Kangkang blood pressure monitor as recommended by the Beijing Hypertension Alliance and verified by the government health department.

Medication compliance included active medication compliance with the doctor’s guidance, based on the prescribed dose, frequency, and method, taking medication after a reminder given by family members, and adhering to medication without interruption or forgetting to take it.

Active health behaviors included non-smoking, low alcoholic consumption, limiting sodium intake, eating more fruits and vegetables, and emotions control. The lifestyle questionnaire and the standard hypertension follow-up form of the Beijing Common Health Record were used to record information about lifestyle habits. Both of these forms are used by the Chinese Government.

The two-way referral aspect included referral from the community hospital to a higher-level hospital and referral from a higher-level hospital to a community hospital.

### 2.5. Statistical analysis

In the present study, the data were analyzed using the SPSS Statistics 20.0 software program. Measurement data were expressed as mean ± standard deviation (\(x \pm SD\)), and count data were expressed as a percentage (%). The normality test was conducted using the Shapiro–Wilk’s test. The homogeneity of variance was evaluated using the F-statistic. Intergroup
comparison was conducted using a paired sample t-test. Non-normally distributed data were compared using a non-parametric test, and counting data were compared using a chi-square test. The categorical data concerning the before/after comparison was analyzed using a paired chi-square test, and \( P < .05 \) was considered statistically significant. The sample size was calculated using the PASS statistical software. The sample size formula is given below:

\[
N = Z^2 \times (P \times (1 - P)) / E^2,
\]

where \( N \) is the sample size, and \( Z \) reflects the statistics, where \( Z = 1.96 \) when the confidence is 95%; \( E \) is the error value, and \( P \) is the probability value. The result of the sample size was 394 and successfully represented the studied population.

3. Results

3.1. General data

A total of 420 patients with hypertension were recruited. Among them, 11 patients were excluded because they had atypical understanding ability (\( n = 5 \)), severe heart disease (\( n = 4 \)), severe kidney dysfunction (\( n = 1 \)), or were pregnant (\( n = 1 \)). Nine patients were lost during follow-up. Finally, 400 patients with hypertension were included in the study analysis (Fig. 1). According to the alternating method, these patients were divided into two groups (\( n = 200 \) for both), that is, an e-intervention and a control group. In the control group, 85 patients were male, and 115 patients were female and their age range was 53 to 67 years. The SBP in this group was 167.87 ± 4.14 mmHg, and the DBP was 120.58 ± 3.57. In the e-intervention group, 79 patients were male, and 121 patients were female, and their age range was 52 to 68 years. The SBP in this group was 167.86 ± 4.15 mmHg, and the DBP was 118.59 ± 3.59. There were no significant differences in terms of smoking, drinking, age, and body mass index between the two groups (\( P > .05 \); Table 1). Lifestyle changes, such as smoking, weight, medication, and daily drug doses were not obvious. The differences in age, sex, and BP between the two groups were not statistically significant. Hence, the two groups were comparable.

3.2. The primary outcomes of blood pressure level

In the present study, BP was taken as the average of three measurements to reduce any bias derived from stress. The SBP and DBP showed significant decreases in both the e-intervention and control groups after management compared with before management. In the e-intervention and control groups, SBP decreased by 41.58 and 13.28 mmHg, respectively, while DBP decreased by 23.42 and 2.09 mmHg, respectively (Table 2). This reflected the good function of the medical center in hypertension management. After management, SBP and DBP were significantly lower in the e-intervention group compared with the control group (Table 2). These results revealed that combining internet technology with medical center services had a better effect on patients’ BP control.

3.3. Good control of hypertension, medication compliance, active health behavior, and two-way referral

In the e-intervention group, the proportion of patients with good control of hypertension, medication compliance, active health behavior, and two-way referral significantly increased compared

![Figure 1. The flowchart.](image-url)
with before management. However, in the control group, the differences in the above indicators before and after management were not statistically significant (Table 3). In addition, after management, the proportion of patients with good control of hypertension, medication compliance, active health behavior, and two-way referral were significantly higher in the e-intervention group compared with the control group (Table 3). These results indicated that combining medical center services and internet technology had a better effect compared with using only conventional medical center services in the management of hypertension. Lifestyle changes, such as smoking, weight, medication, and daily doses were not obvious.

4. Discussion

The present study results revealed that, compared with a pre-management context, SBP and DBP significantly decreased in both the e-intervention and control groups after management. Furthermore, compared with before receiving management, the proportion of patients with good control of hypertension, medication compliance, active health behavior, and two-way referral significantly increased in the e-intervention group. However, the difference in the above indicators before and after applying management was not statistically significant in the control group. In addition, the proportion of patients with good control of hypertension, medication compliance, active health behavior, and two-way referral were significantly higher in the e-intervention group compared with the control group.

China has undergone substantial economic development and social changes in the past three decades, and the disease spectrum of Chinese residents has significantly changed. Chronic, non-communicable diseases have become a major threat to the health of residents, have developed into primary causes of premature death, and threaten the health of the labor force.[4–8] Hypertension is one of the most common chronic non-infectious diseases in China. Due to a lack of health awareness among residents, there is an urgent need to improve overall health and chronic disease management among these individuals, starting with a focus at the community level.[9–11] The goal of hypertension control is to reduce the risk of cardiovascular and cerebrovascular events.[12–15] In China, 90% of patients with hypertension were treated in basic level medical units, rendering them the primary frontlines for hypertension prevention and treatment.[16–19]

Medical institutions generally include the integration of medical resources in their region, through which secondary or tertiary level hospitals integrate with several community hospitals or village clinics. At present, the medical complex typically employs four relatively mature organizational modes, that is, the medical group mode, the medical community mode, the cross-regional specialty alliance mode, and the telemedicine network mode. In the present study, all community residents in the region covered by the medical complex had established health records and signed contracts with family doctors. The family doctor contracts can assist in improving the awareness rate of community residents in relation to health knowledge and significantly improve the treatment compliance and quality of life of patients with chronic diseases, such as hypertension. Yao et al revealed that after signing contracts with family doctors, patients’ awareness rate of hypertension-related knowledge significantly improved, as did the treatment compliance of study

### Table 1
The comparison of general data between the two groups.

| Groups           | Male/female | Smoker/non-smokers | Drinker/non-drinker | Age | BMI |
|------------------|-------------|--------------------|---------------------|-----|-----|
| E-intervention group | 85/115      | 25/175             | 37/163              | 64.8±6.7 | 24.85±3.21 |
| Control group    | 79/121      | 31/169             | 35/165              | 62.1±4.9 | 24.67±3.36 |

### Table 2
The comparison of blood pressure level between the two groups (x±SD, mmHg).

| Groups           | n  | SBP          | DBP          |
|------------------|----|--------------|--------------|
|                  |    | Before       | After        | Before       | After        |
| E-intervention group | 200 | 167.86±4.15  | 126.28±3.59a,b | 118.59±3.59  | 95.17±3.55a,b |
| Control group    | 200 | 167.87±4.14  | 154.59±3.54a,b | 120.58±3.57  | 118.49±3.58a,b |

SBP = systolic blood pressure. DBP = diastolic blood pressure.

*a Compared with before management, the blood pressure level was significantly decrease after management, P<.05.

*b After management, the blood pressure level of e-intervention group was significantly lower than control group, P<.05.

### Table 3
The comparison of medication compliance between the two groups (n).

| Groups           | Reach the standard of blood pressure | Medication compliance | Active health behavior | Two-way referral |
|------------------|-------------------------------------|-----------------------|-----------------------|------------------|
|                  | Before     | After     | Before     | After     | Before     | After     | Before     | After     |
| E-intervention group | 200       | 87        | 141a,b     | 127       | 161a,b     | 85        | 142a,b     | 42        | 75a,b     |
| Control group    | 200       | 92        | 102        | 123       | 138        | 90        | 102        | 39        | 49        |

*a Compared with before management, the proportion of patients with a good control of hypertension, medication compliance, active health behavior and two-way referral significantly increased, P<.05.

*b After management, the proportion of patients with a good control of hypertension, medication compliance, active health behavior and two-way referral were significantly higher in the e-intervention group than in the control group, P<.05.
subjects. To some degree, family doctor contracts can improve the trust of residents in terms of community healthcare and provide a solid foundation for the implementation of hierarchical diagnosis and treatment. In addition, this can increase the compliance of patients, which is particularly suitable for young and middle-aged individuals with hypertension who reflect poor treatment compliance, who cannot be regularly followed up in outpatient clinics, and who lack knowledge about hypertension treatment in general. The present study also revealed that medical centers providing routine management can also effectively reduce the BP level of patients with hypertension.

From a practical perspective, considering that there is currently a shortage of human resources available in the form of community doctors in China, the health and disease management services contracted by family doctors cannot be popularized and cannot meet the actual needs involved in whole-process health and disease management. Based on these circumstances, internet tools that are not limited by space and time, as well as intelligent tools based on scientific knowledge and expert experience may play a useful role in the management of patients with chronic diseases. Adopting internet technology within medical centers is conducive for the penetration of medical resources and the sharing of health information. It is also beneficial for the development of appointment diagnosis and treatment, and two-way diagnosis and treatment. Lu et al reported that remote internet-based monitoring could effectively enhance the management ability of BP monitoring among patients with hypertension and improve the control rate of BP, which reflects an effective approach for managing hypertension. Yan et al reported that application measures, with the internet as a carrier and technical facilitator, could provide patients with intelligent and personalized services and effectively increase awareness, treatment, and control rates, and improve the management effect of patients with hypertension within a community.

The present study also revealed that the application of internet technology in medical centers, based on the hypertension management APP, could effectively improve the management of patients with hypertension, increase the proportion of patients with good medication compliance, active health behavior, and two-way referral, and finally, reduce BP levels and improve the proportion of patients with good BP control. Habibovic et al reported that the Do CHANGE service integrates new technologies into a behavior-change intervention that helps to modify the unhealthy lifestyles of patients with cardiac issues. [201] Alessa et al reported that mobile applications may be effective for lowering BP and were broadly accepted by users. [211] Mars et al found that many countries have begun using numerous spontaneous telemedicine services via the WhatsApp Messenger application. [221] According to a study of BP changes, the risk of premature death in an electronic intervention group appeared to have been reduced to 25%. [221] In addition to using a mobile application, the medical center can provide remote consultation, remote electrocardiogram diagnosis, remote image diagnosis, and other services to basic level medical units using artificial intelligence and other technical means. It can promote real-time access, mutual recognition, and the sharing of inspection and test results among different medical teams and departments within the medical center. In this way, more information can be provided to support the medical treatment and chronic disease management of patients, reduce the burden of medical treatment for patients, and continuously improve the capacity and efficiency of the medical services in basic-level medical units.

The present study included the following limitations. First, the patients were divided into two groups according to the alternating method, and no blinding was effected. Therefore, a risk of bias exists. Second, the sample size included in the present study was small. According to our calculation, the sample size met the typical standard; however, we would have preferred having a larger sample study to compensate for a lack of data. Hence, multi-center clinical trials with larger sample sizes are needed. Finally, the clinical follow-up time of the present study was 1 year. The long-term prognosis of patients with hypertension requires a prolonged follow-up time for additional observation.

5. Conclusion

The application of internet technology in medical settings can help to decrease BP and improve the effective management of middle-aged and older patients with hypertension in communities.

Author contributions

Conceptualization: Bai-Ding Yin, Jing Wang.
Data curation: Bai-Ding Yin, Da-Hong Tu, Nuo Yang.
Investigation: Bai-Ding Yin, Da-Hong Tu, Nuo Yang, Jing Wang.
Methodology: Nuo Yang.
Project administration: Jing Wang.
Resources: Bai-Ding Yin, Da-Hong Tu, Nuo Yang, Jing Wang.
Software: Da-Hong Tu.
Supervision: Jing Wang.
Writing – original draft: Bai-Ding Yin.
Writing – review & editing: Bai-Ding Yin, Jing Wang.

References

[1] Yang C, Wang H, Zhao X, et al. CKD in China: evolving spectrum and public health implications. Am J Kidney Dis 2019;74(4):638-46.
[2] Wu Y, Guo Z, Fu X, et al. The study protocol for the China Health Big Data (China Biobank) project. Quant Imaging Med Surg 2019;9:905–102.
[3] Si X, Zhai Y, Zhu XL, Ma JX. The changing trend of capacity on policy implementation related to the prevention and control of chronic non-communicable disease at the provincial level, from 2011 to 2017. Zhonghua Liu Xing Bing Xue Za Zhi 2018;39:726–30. [Article in Chinese].
[4] Li XI, Ma JX, Wu J, Zhu XL. Enlightenment of the United Nations high-level summit on non-communicable disease prevention and control on the development of public health system in China. Zhonghua Yu Fang Yi Xue Za Zhi 2019;53:545–58. [Article in Chinese].
[5] National Basic Public Health Service Program Primary Hypertension Management Office; Primary Hypertension Management Expert CommitteeNational guidelines for the management of primary hypertension prevention and treatment. Chin Circ J 2017;32:1041–8. [Article in Chinese].
[6] Zhang S, Jiang YY, Dong WL, Mao F, Dong QJ. Trend on mortalities in all-cause and chronic non-communicable diseases among the labor force population in China, 2007–2016. Zhonghua Liu Xing Bing Xue Za Zhi 2018;39:1582–8. [Article in Chinese].
[7] Wang N, Guo Y, Traditional Chinese Practice. A promising integrative intervention for chronic non-infectious disease management. Chin J Integr Med 2018;24:886–90.
[8] Yan LL, Kong L. China’s multisectoral approach to Chronic disease. Glob Heart 2016;11:441–2.
[9] Kawazoe N, Zhang X, Chiang C, et al. Prevalence of hypertension and hypertension control rates among elderly adults during the cold season in rural Northeast China: a cross-sectional study. J Rural Med 2018;13:64–71.
[10] Wang MY, Tang X, Qin XY, et al. Progress in research of family-based cohort study on common chronic non-communicable diseases in rural population in northern China. Zhonghua Liu Xing Bing Xue Za Zhi 2018;39:94–7. [Article in Chinese].

[11] Shao S, Hua Y, Yang Y, et al. Salt reduction in China: a state-of-the-art review. Risk Manag Healthcare Policy 2017;10:17–28.

[12] Viera AJ. Screening for hypertension and lowering blood pressure for prevention of cardiovascular disease events. Med Clin North Am 2017;101:701–12.

[13] Bundy JD, Mills KT, He J. Comparison of the 2017 ACC/AHA hypertension guideline with earlier guidelines on estimated reductions in cardiovascular disease. Curr Hypertens Rep 2019;21:76.

[14] Baker-Goering MM, Howard DH, Will JC, Beeler Asay GR, Roy K. Association between self-reported hypertension and antihypertensive medication use and cardiovascular disease-related events and expenditures among patients diagnosed with hypertension. Public Health Rep 2019;134:493–501.

[15] Palatini P, Saladini F, Mos L, et al. Short-term blood pressure variability outweighs average 24-h blood pressure in the prediction of cardiovascular events in hypertension of the young. J Hypertens 2019;37:1419–26.

[16] Li Y, Yang L, Wang L, et al. Burden of hypertension in China: a nationally representative survey of 174,621 adults. Int J Cardiol 2017;227:516–23.

[17] Lu J, Lu Y, Wang X, et al. Prevalence, awareness, treatment, and control of hypertension in China: data from 1·7 million adults in a population-based screening study (China PEACE Million Persons Project). Lancet 2017;390:2549–58.

[18] Bundy JD, He J. Hypertension and related cardiovascular disease burden in China. Ann Glob Health 2016;82:227–33.

[19] Wang JG. New era of hypertension research in China. Zhonghua Xin Xue Guan Bing Za Zhi 2019;47:718–21.

[20] Habibovic M, Broers E, Piera-Jimenez J, et al. Enhancing lifestyle change in cardiac patients through the Do CHANGE System (“Do Cardiac Health: Advanced New Generation Ecosystem”): randomized controlled trial protocol. JMIR Res Protoc 2018;7:e40.

[21] Alessa T, Abdi S, Hawley MS, de Witte L. Mobile apps to support the self-management of hypertension: systematic review of effectiveness, usability, and user satisfaction. JMIR Mhealth Uhealth 2018;6:e10723.

[22] Mars M, Scott RE. WhatsApp in clinical practice: a literature review. Stud Health Technol Inform 2016;231:82–90.