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"Internet+" Mobile Application for Blood Pressure Management in Hypertensive Patients: A Meta-Analysis

Xuan Fan[1], Jinzhen Jin[1,*]

[1] School of Nursing, Yanbian University, Yanji 133000, China

[*] Corresponding Author

Abstract

Objective: To investigate the effectiveness of mobile applications in blood pressure control. Methods: Randomized controlled trials (RCTs) examining the effects of "Internet+" mobile application-based nursing interventions on blood pressure management in hypertensive patients were retrieved from five databases: China National Knowledge Infrastructure (CNKI), Wanfang, VIP, PubMed, and Embase. The search spanned up to April 7, 2024. Following literature screening, abstract review, and risk-of-bias assessment, a meta-analysis was conducted using RevMan 5.4.1 software. Results: Seven studies were included, with the following outcome measures analyzed: ① Systolic blood pressure (SBP): MD = 2.60, 98% CI (1.47, 3.73), P < 0.05; ② Diastolic blood pressure (DBP): MD = 1.63, 98% CI (0.52, 2.75), P < 0.05; ③ Medication adherence: SMD = 0.36, 98% CI (0.21, 0.51), P < 0.05. Conclusion: "Internet+" mobile healthcare nursing interventions significantly improve blood pressure management outcomes in hypertensive patients, enhance medication adherence, and promote better blood pressure control.

Keywords

Hypertension; Internet+; Meta-analysis.

1. Introduction

Hypertension is a condition characterized by elevated systemic arterial pressure, with the majority of patients exhibiting no overt symptoms. Regular blood pressure monitoring remains an effective method for its diagnosis. Hypertension can lead to multi-organ damage, with cardiac complications being particularly severe and ranking as the leading cause of mortality in China [1]. If left untreated, hypertension not only induces physiological abnormalities but also exerts a detrimental impact on psychological well-being [2-3]. With advancements in medical science and the widespread adoption of the Internet, enhanced interaction between healthcare providers and patients has facilitated dynamic monitoring and intervention of patient behaviors, enabling better management of complications and their progression [4-6]. Existing studies suggest that mobile application-based interventions under the "Internet+" model can significantly control blood pressure and improve medication adherence [7]. This study conducted a meta-analysis of RCTs evaluating the effects of "Internet+" mobile application nursing interventions on blood pressure management and medication adherence in hypertensive patients, aiming to provide a scientific basis for optimizing future hypertension care models.

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2. Materials and Methods

2.1. Literature Retrieval

2.1.1. Search Databases

This study utilized computer-based searches across five major databases: PubMed, Embase, China National Knowledge Infrastructure (CNKI), Wanfang, and VIP. The search period extended from the inception of each database to April 7, 2024. A combination of subject headings and free-text terms was employed to ensure comprehensive retrieval of relevant literature.

2.1.2. Literature Search Strategy

For Chinese-language searches, the strategy included: "hypertension" AND ("mobile application" OR "mobile app" OR "APP" OR "telephone" OR "WeChat" OR "text message") AND ("medication adherence" OR "drug compliance" OR "medication compliance" OR "drug adherence"). For English-language searches, the strategy was: ("hypertension" OR "Blood Pressure, High" OR "Blood Pressures, High" OR "High Blood Pressure") AND ("Mobile Applications" OR "Application, Mobile" OR "Portable Software Apps" OR "Smartphone Apps" OR "Portable Electronic Apps") AND ("Smartphone" OR "Cell Phone" OR "cell telephone" OR "Mobile phone") AND ("WeChat") AND ("text message" OR "Messaging, Text" OR "Texting" OR "Short Message Service" OR "Text Messages" OR "Message, Text") AND ("Medication Adherence" OR "Adherence, Medication" OR "Drug Adherence" OR "Adherence, Drug" OR "Medication Nonadherence" OR "Nonadherence, Medication").

2.2. Inclusion and Exclusion Criteria

Inclusion Criteria: ① Individuals diagnosed with hypertension and receiving antihypertensive drug therapy; ② Age ≥ 18 years; ③ Patients capable of self-administering medication, managing daily activities, and communicating without difficulty; ④ Studies must be randomized controlled trials (RCTs) evaluating mobile application interventions for hypertensive patients; ⑤ Experimental groups utilized mobile applications as an intervention or in combination with routine care, while control groups received only routine care; ⑥ Primary outcome measures included blood pressure levels and medication adherence scores.

Exclusion Criteria: ① Studies with duplicate publications; ② Literature lacking specific data; ③ Studies without clearly defined intervention durations.

2.3. Literature Screening and Data Extraction

Literature Screening: ① Removal of duplicate studies; ② Preliminary assessment of relevance based on titles and abstracts; ③ Full-text review to further select eligible studies according to inclusion and exclusion criteria.

Data Extraction: ① Basic study details (e.g., author, publication location, and year); ② Specific intervention details, including methods and duration; ③ Characteristics of study participants; ④ Risk-of-bias assessment; ⑤ Outcome measure data.

2.4. Literature Quality Assessment

This study adhered to evidence-based medicine principles and utilized the Chinese version of the Cochrane Risk of Bias Handbook (Version 5.1.0) to evaluate the quality of selected RCTs. Study quality was classified into three levels: Grade A (fully meeting standards), Grade B (partially meeting standards), and Grade C (failing to meet any standards). Discrepancies

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during evaluation were resolved through discussion with a third researcher until consensus was reached.

2.5. Statistical Methods

Data analysis was performed using RevMan 5.3 software. Mean difference (MD) was used as the effect measure for changes in systolic and diastolic blood pressure, while standardized mean difference (SMD) was applied for medication adherence comparisons. Heterogeneity between studies was assessed using the Q test and I^2 statistic, with statistical significance set at $P < 0.05$.

3. Results

3.1. Literature Screening Process and Results

The initial database search retrieved 870 articles: 174 from CNKI, 161 from VIP, 280 from Wanfang, 54 from PubMed, and 201 from Embase. After deduplication using NoteExpress software and screening based on predefined criteria, seven relevant studies [8-14] were selected, including two Chinese-language studies [8-9] and five foreign-language studies [10-14]. The screening process and results are illustrated in Figure 1.

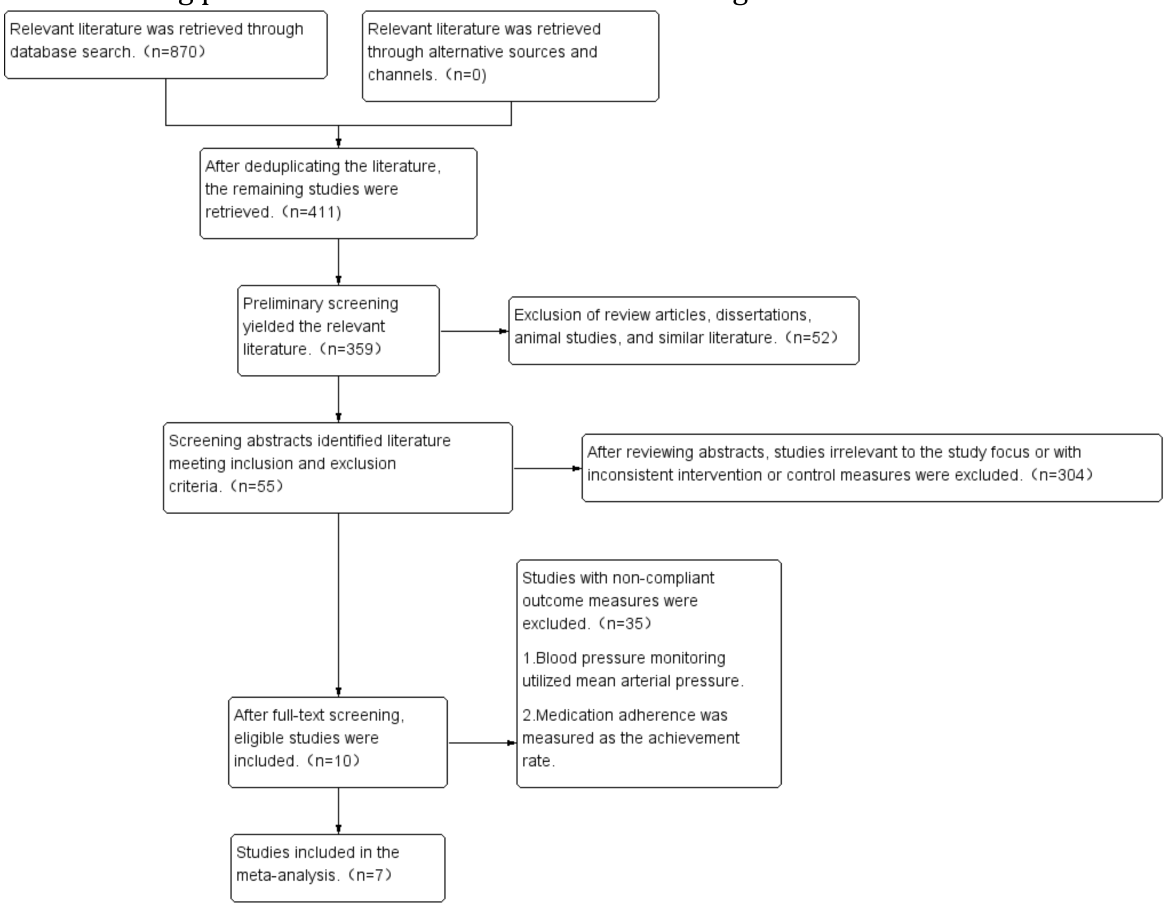

Figure 1: Overall Flowchart of Literature Screening Process

3.2. Baseline Characteristics of Included Studies

The seven included studies involved 1,430 patients, all aged over 51 years. Mobile application interventions included: ① Smartphone apps; ② Smart blood pressure monitors; ③

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Smartphone-based monitoring; ④ WeChat. Medication adherence was primarily measured using the MMAS-8 scale or its modified versions. Baseline characteristics of the included studies are presented in Table 1.

Table 1: Basic characteristics of included literature (n=7)

Included Studies	Year		Sample Size	Age (Years)	Intervention	Outcome Measures
Huang YN, et al.	2021	E	52	59.42±9.22	Routine Care + WeChat	1，2，3（TAQPH）
		C	51	58.37±8.93	Routine Care	
Gong, K, et al.	2020	E	225	58.20±7.479	Application	1，2，3(Modified MMAS-8)
		C	218	59.27±7.439	Routine Care	
Morawski, K, et al.	2018	E	209	51.7±10.5	Application	1,3（MMAS-8）
		C	202	52.4±10.1	Routine Care	
Wang, S, et al.	2023	E	24	59.7±7.4	Application	1，2，3（TAQPH）
		C	25	60.1±9.3	Routine Care	
Sheilini M, et al.	2019	E	64 ≥60-70	45participants	Application	1，2，3(Modified MMAS-8)
			＞70	19participants		
		C	60 ≥60-71	40participants	Routine Care	
			＞71	20participants		
Liu HX, et al.	2020	E	120	68±4.7	Application	3（MMAS-8）
		C	120	68±5.1	Routine Care	
Sarfo,F, et al.	2018	E	30	54.3±8.00	Smart Monitoring	1，2，3（MASS-8）
		C	30	55.9±13.7	Routine Care	

Note: E represents the experimental group, C represents the control group; 1. Systolic Blood Pressure, 2. Diastolic Blood Pressure, 3. Medication Adherence (MMAS-8, Modified MMAS-8, TAQPH)

3.3. Quality Assessment of Included Studies

All seven included studies [8-14] were RCTs, and following quality assessment, they were all classified as Grade B. Detailed results are shown in Figure 2. Key sources of bias included the lack of blinding and incomplete outcome data reporting.

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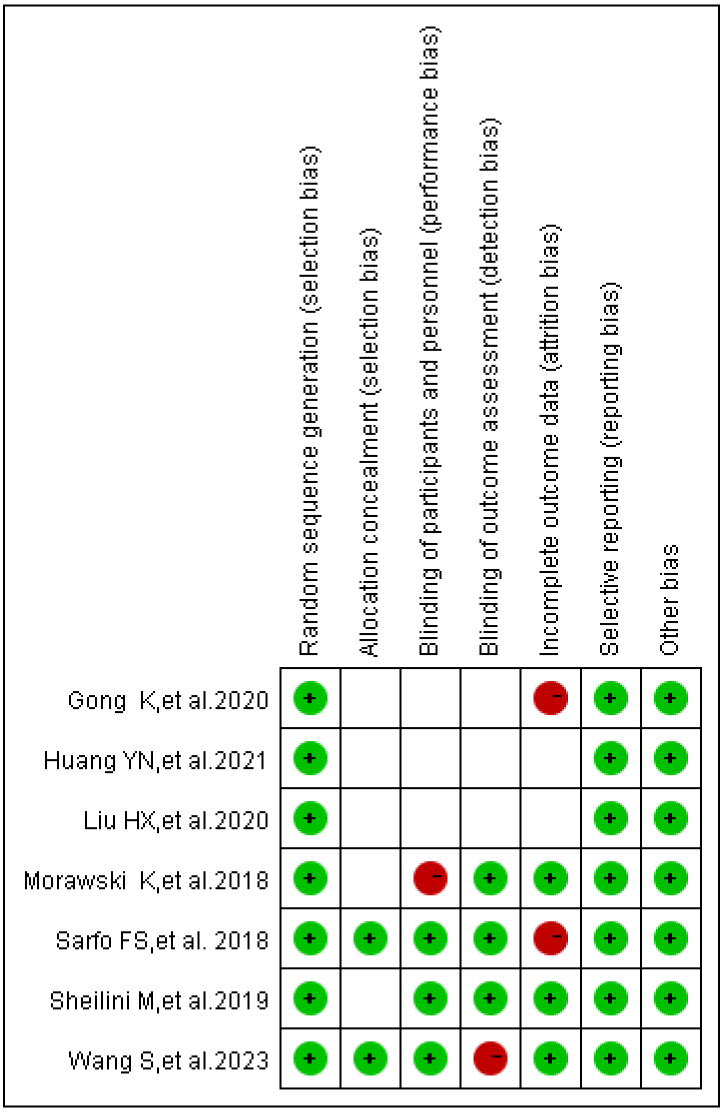

Figure 2: Literature Quality Assessment Figure

3.4. Meta-Analysis Results

3.4.1. Analysis of Systolic Blood Pressure in Hypertensive Patients

Six studies [8, 10-14] with countable data were included and subjected to heterogeneity testing. Results showed I^2 = 34%, Q test P = 0.18, indicating low heterogeneity. A fixed-effects model was applied for meta-analysis. The MD across six studies was 2.60, 95% CI (1.47, 3.73), Z = 4.51, P < 0.01. As shown in Figure 3, mobile application interventions significantly outperformed routine care in reducing systolic blood pressure.

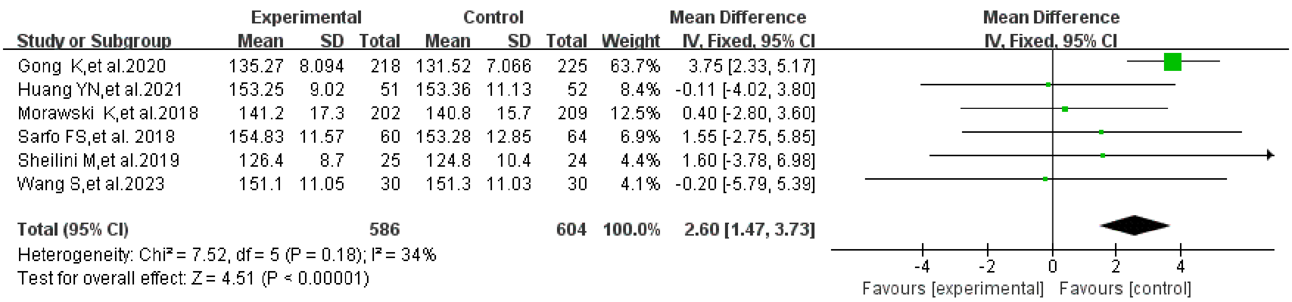

Figure 3: Meta-Analysis Results for Systolic Blood Pressure

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3.4.2. Analysis of Diastolic Blood Pressure in Hypertensive Patients

Six studies [8, 10-14] were included and tested for heterogeneity, yielding I^2 = 67%, Q test P = 0.01, indicating significant heterogeneity. Sensitivity analysis identified Morawski et al. [11] as a major contributor to heterogeneity. After excluding this study, heterogeneity decreased (I^2 = 0%, Q test P = 0.93). A fixed-effects model was then applied to the remaining five studies [8, 10, 12-14], resulting in an MD of 1.63, 95% CI (0.52, 2.75), Z = 2.86, P = 0.004. As shown in Figure 4, mobile application interventions significantly reduced diastolic blood pressure compared to routine care.

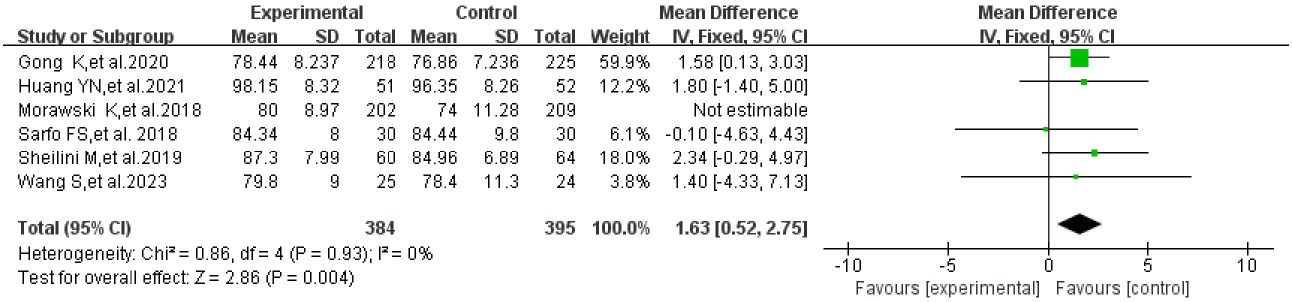

Figure 4: Meta-Analysis Results for Diastolic Blood Pressure

3.4.3. Analysis of Medication Adherence in Hypertensive Patients

Six studies [8-9, 11-14] were included and tested for heterogeneity, with I^2 = 59%, Q test P = 0.03, indicating significant heterogeneity. Sensitivity analysis revealed that Huang et al. [8] significantly influenced heterogeneity. After excluding this study, heterogeneity was no longer significant (I^2 = 36%, Q test P = 0.18). A fixed-effects model was applied to the remaining five studies [9, 11-14], yielding an SMD of 0.36, 95% CI (0.21, 0.51), Z = 4.63, P < 0.001. As shown in Figure 5, mobile application interventions significantly improved medication adherence compared to routine care.

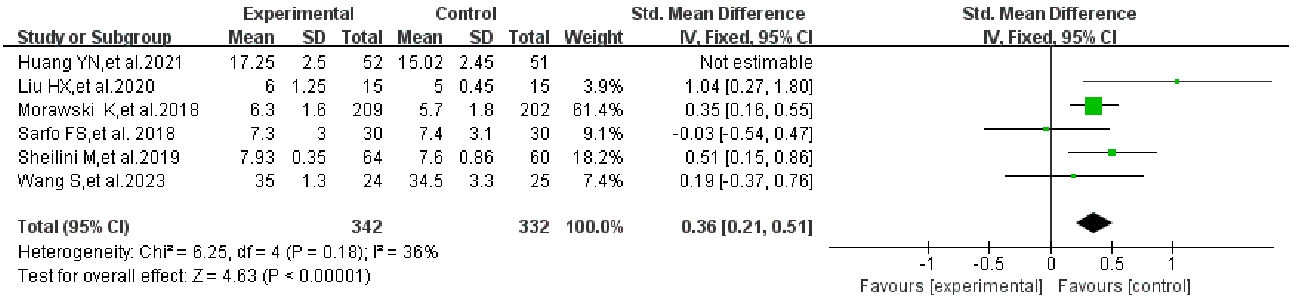

Figure 5: Meta-Analysis Results for Medication Adherence

4. Discussion

This meta-analysis included seven original studies [8-14], with six providing extractable data on diastolic blood pressure and medication adherence. In the diastolic blood pressure analysis, excluding the highly heterogeneous study by Morawski et al. [15] resulted in an MD of 1.63, 95% CI (0.52, 2.75), P < 0.05, confirming a significant intervention effect. Heterogeneity analysis suggested that differences in intervention methods in Morawski et al. [11] may have contributed to increased variability. For medication adherence, excluding the heterogeneous

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study by Huang et al. [12] yielded an SMD of 0.36, 95% CI (0.21, 0.51), $P < 0.05$, demonstrating that mobile application interventions outperformed routine care in enhancing adherence. These findings indicate that mobile application interventions effectively lower blood pressure and improve health outcomes in hypertensive patients.

5. Conclusion

Pharmacological treatment of hypertension effectively reduces mortality [15], underscoring the importance of blood pressure control. This analysis confirms that adherence to antihypertensive medications and blood pressure management are critical in hypertension care. Mobile applications provide convenience, significantly reduce costs, and enable healthcare providers to monitor patients in real-time, offer personalized services, and adjust treatment plans promptly. Additionally, they deliver health education, enhance disease awareness, provide psychological support, and boost treatment confidence. However, limitations such as the limited numberExcerpt of outcome measures and inconsistent assessment tools in some studies suggest that these findings require further validation. Future high-quality studies are needed to corroborate these results.

References

[1] Bi HT, Su J, Chen LL, et al. Prevalence, blood pressure control, and related factors analysis of hypertension among residents aged 35–75 in Jiangsu Province [J]. Chinese Journal of Epidemiology, 2024, 45(07): 947-954.

[2] Cui M, Wang J, Deng M, et al. The interaction between hypertension comorbidity patterns and social participation on depressive symptoms in middle-aged and older Chinese adults [J]. Health Research, 2024, 53(05): 694-700.

[3] Zhang YY, Ni CY, Jin Y, et al. Effects of hypertension and dyslipidemia on cognitive function in urban elderly residents [J]. Journal of Shanghai Jiaotong University (Medical Science), 2024, 44(07): 907-914.

[4] World Health Organization. Global Observatory for e-Health Series - Volume 3. (2011-06-07) [Accessed 2020-11-20].

[5] Wang P, Zhao QH, Xiao MC, et al. Advances in the application of mobile healthcare in health education for patients with coronary heart disease [J]. Chinese Nursing Management, 2018, 18(7): 953-958.

[6] Chen HH, Wang GL. Perspectives on the regulatory model of mobile healthcare in China under the "Internet+" framework [J]. Chinese Hospital Management, 2016, 36(10): 30-33.

[7] Mohammadi R, Ayatolahi TM, Hoveidamanesh S, et al. Reflection on mobile applications for blood pressure management: A systematic review on potential effects and initiatives [J]. Studies in Health Technology and Informatics, 2018, (247): 306-310.

[8] Huang YN, Zhao Y, Liu G, Wan YF. Application effects of WeChat-based mobile health education in hypertensive patients [J]. China Contemporary Medicine, 2021, 28(18): 218-221.

[9] Liu HX, Hu YL, Zhao LM. Application of mobile internet in blood pressure management of elderly hypertensive patients [J]. Electronic Journal of Practical Clinical Nursing Science, 2020, 5(35): 5, 10.

[10] Gong K, Yan YL, Li Y, et al. Mobile health applications for the management of primary hypertension: A multicenter, randomized, controlled trial [J]. Medicine, 2020, 99(16): e19715.

[11] Morawski K, Ghazinouri R, Krumme A, et al. Association of a smartphone application with medication adherence and blood pressure control: The MedISAFE-BP randomized clinical trial [J]. JAMA Internal Medicine, 2018, 178(6): 802-809.

ISSN: 3079-6601

[12] Wang S, Leung M, Leung SY, et al. Safety, feasibility, and acceptability of telemedicine for hypertension in primary care: A proof-of-concept and pilot randomized controlled trial (SATE-HT) [J]. Journal of Medical Systems, 2023, 47(1): 34.

[13] Sarfo FS, Treiber F, Gebregziabher M, et al. Phone-based intervention for blood pressure control among Ghanaian stroke survivors: A pilot randomized controlled trial [J]. International Journal of Stroke, 2019, 14(6): 630-638.

[14] Sheilini M, Hande HM, Prabhu MM, et al. Impact of multimodal interventions on medication nonadherence among elderly hypertensives: A randomized controlled study [J]. Patient Preference and Adherence, 2019, 13: 549-559.

[15] Liu JH, Liu J. A brief review of the 2023 European Society of Hypertension guidelines for the management of hypertension [J]. Chinese Journal of Hypertension, 2023, 31(10): 908-910.