Evaluate effect of the National Essential Public Health Service Package on blood pressure control of Chinese people with hypertension: a retrospective population-based retrospective longitudinal study

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Abstract

Background: The National Essential Public Health Service Package was launched in 2009 to tackle poor blood pressure control of Chinese people with hypertension. However, effect of The National Essential Public Health Service Package on blood pressure control is still unclear.

Objective: In a retrospective population-based retrospective longitudinal study, we aimed to evaluate effect of the National Essential Public Health Service Package on blood pressure control.

Methods: A total of 516777 patients registered in the National Essential Public Health Service Package were included in this study. The blood pressure control data was assessed based on the Residence Health Record System dataset. We longitudinally evaluated effects of the NEPHSP on blood pressure control by analyzing changes of blood pressures measured via regular follow-ups that were quarterly conducted. Both of level and trend (slope) of the blood pressure outcome changes were analyzed. We conducted stratified analysis to explore blood pressure control effects of the NEPHSP among subgroup participants with specific characteristics.

Results: The baseline mean (SD) values of SBP and DBP were 147.12(19.88) mm/Hg and 85.11(11.79) mm/Hg. The control rates of baseline SBP and DBP were 39.79% and 69.21%. SBP mean values quarterly decreased by 5.06 mm Hg (95% CI, -5.11 to -5.00, P<0.001), 6.69 mm Hg (95% CI, -6.74 to -6.63, P<0.001), 10.30 mm Hg (95% CI, -10.34 to -10.23, P<0.001), 6.63 mm Hg (95% CI, -6.68 to -6.57, P<0.001). SBP control rates quarterly increased to 53.12% (0.60, 95% CI, 0.59 to 0.61, P<0.001), 56.61% (0.76, 95% CI, 0.75 to 0.77, P<0.001), 63.40% (1.08, 95% CI, 1.07 to 1.09, P<0.001), 55.09% (0.69, 95% CI, 0.68 to 0.70, P<0.001). DBP mean value quarterly decreased by 1.75 mm Hg (95% CI, -1.79 to -1.72, P<0.001), 2.64 mm Hg (95% CI, -2.68 to -2.61, P<0.001), 4.20 mm Hg (95% CI, -4.23 to -4.16, P<0.001), 2.64 mm Hg (95% CI, -2.68 to -2.61, P<0.001). DBP control rates quarterly increased to 78.11% (0.52, 95% CI, 0.51 to 0.53, P<0.001), 80.32% (0.67, 95% CI, 0.66 to 0.68, P<0.001), 83.17% (0.89, 95% CI, 0.88 to 0.90, P<0.001), 79.47% (0.61, 95% CI, 0.60 to 0.62, P<0.001). Older age group a larger decrease in SBP mean values (0.87, 95% CI, 0.85 to 0. 90, P<0.001) and a larger increase in SBP control rates (0.054, 95% CI, 0.051 to 0.058, P<0.001). The participants with CVD had smaller decrease in SBP mean values (-0.38, 95% CI, -0.41 to -0.35, P<0.001) and smaller increase in SBP control rates (-0.041, 95% CI, -0.045 to -0.037, P<0.001) than the blood pressures outcomes of participants without CVD.

Conclusions: The NEPHSP was effective on improving blood pressure control of Chinese people with hypertension. Blood pressure control of the older and participants with CVD need to be intensified.

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Original Manuscript

Evaluate effect of the National Essential Public Health Service Package on blood pressure control of Chinese people with hypertension: a retrospective population-based retrospective longitudinal study

Introduction

The Global Burden of Disease study reported that cardiovascular diseases (CVD) are the leading non-communicable disease contributing to disease-adjusted life years increase in China [1-3]. Hypertension that was considered as the major modifiable risk factor for CVD is prevalent in China [4-12]. According to the data of a recent survey conducted in national wide, the prevalence of hypertension was evaluated at 44.7% among Chinese adults over 18 years old, and reportedly merely 30.1% of Chinese adults with hypertension accepting anti-hypertensive treatments [13]. The low level of hypertension treatment rate leaded to suboptimal control of blood pressures among Chinese adults with hypertension [13]. Merely 7.2% of Chinese adults with hypertension had their blood pressures under control [13].

To tackle the poor hypertension control and growing burden of CVD, Chinese government launched the National Essential Public Health Service Package (NEPHSP) in 2009 [14]. NEPHSP was a set of public health services which were available for all community-dwelling residents [14-18]. The public health services contain four modules, which are screening, monitoring, regular follow-up and individualized interventions for hypertension control. The four modules were provided by primary health care professionals [14-18].

The NEPHSP registration has been continuously expanded since it has been launched in 2009 [14,18]. A total of 109 million Chinese adults diagnosed with hypertension registered with NEPHSP from 2009 to 2019 [14]. The government investment increased from 15 to 84 RMB per person annually [15,18]. Because the registration expansion and investment increase on the NEPHSP, the proportion of Chinese adult with hypertension who accept anti-hypertensive treatment increased by 29.28% from 2009 to 2019 [14,18].

Although the registration expansion and investment increase on the NEPHSP improved hypertension treatment rate, the NEPHSP lack quality-oriented evaluations, which leads to an uncertainty whether the NEPHSP is effective on blood pressures control [14-18].

Furthermore, research evidence demonstrating effectiveness of the NEPHSP on blood pressures control of Chinese adults with hypertension [14-18]. To fulfill the research gap, this study aimed to explore effect of the NEPHSP on blood pressures control of Chinese adult with hypertension.

Methods

Study design

Using a retrospective longitudinal study design to analyzing data repetitively measured, we explored the effects of the NEPHSP on blood pressure control. We involved participants who accepted hypertension care services of the NEPHSP in 2023. Firstly, we evaluated baseline outcomes that were measured before the participants accepted hypertension care services of the NEPHSP. Based on the baseline outcomes, we longitudinally evaluated effects of the NEPHSP on blood pressure control by analyzing changes of blood pressures measured via regular follow-ups that were quarterly conducted. Both of level and trend (slope) of the blood pressure outcome changes were analyzed.

The data of this study was extracted from the Residence Health Record System, which is an electronic health record system built to recording demographic and health information of people registering with the NEPHSP [16,17]. This study used data of the Residence Health Record System built in Jining city, which is a national pilot city of Chronic Disease Comprehensive Prevention and Control programs and locates in eastern China.

Study Participants

We involved the NEPHSP participants from 1393 primary care institutions of the nine districts in Jining City. Eligibility criteria were: (1) individuals registering with the NEPHSP as hypertensive patient; (2) individuals had records of annual health examinations in 2022; (3) individuals accepted healthcare services of the NEPHSP in 2023; (4) individuals had records of follow-up quarterly conducted in 2023.

Intervention

The NEPHSP were divided into four dimensions: screening, routine follow-up, individualized interventions, and annual health examinations. The explicit flowchart of the NEPHSP was described in Figure 1.

The screening was conducted at primary care institutions when community residents had an appointment with primary healthcare professionals. The criteria for hypertension diagnosis were systolic blood pressure (SBP) over 140 mmHg or diastolic blood pressure (DBP) over 90 mmHg in three separate measurements in different single days. The residents were invited to register with NEPHSP if they were diagnosed as hypertension.

Routine follow-up contained five facets: (1) assessing emergency conditions, (2) evaluating hypertensive symptoms, (3) blood pressure measurements, (4) evaluating healthy behaviors, (5) evaluating medication treatment regimens and treatment compliance. Assessing emergency conditions was the first part of routine follow-up. The participants would be referred to secondary or tertiary care settings if there were emergency conditions that were hard to tackle in primary care institutions. If no emergency condition was identified, the rest parts would be conducted. The regular follow-ups were quarterly provided.

The individualized interventions were formulated according to the regular follow-up. According to the assessments of regular follow-up individualized interventions were categorized into four dimensions: (1) if blood pressures were under control, no adverse drug reactions and no occurrence of comorbidities or aggravation of comorbidities were identified, the next follow-ups were made for the participants. (2) If blood pressures were uncontrolled or adverse drug reactions were recognized at the first time, the primary healthcare professionals would adjust anti-hypertensive medication regimes. The conditions of participants would be re-evaluated within two weeks. (3) If the patients had refractory

uncontrolled blood pressures or adverse drug reactions that could not be tackled in primary care settings, or occurrence and aggravation of comorbidities, the primary healthcare professionals would refer the participants to secondary or tertiary care settings. The conditions of participants would be re-evaluated within two weeks. (4) Goal-settings were available for all participants. The primary health care professionals developed shared goals to increase heathy behaviors for the participants. The achievement of heathy behavior goals would be assessed at the routine follow-ups.

Annual health examinations were available for all patients. The health examinations contained overall physical and bio-clinical examinations, lifestyle and medication treatment evaluations.

Outcome Variables

SBP and DBP mean values and control rates were analyzed as the study outcomes. we evaluated (1) changes in mean values of SBP and DBP (2) changes in control rates of SBP and DBP. The threshold of controlled SBP/DBP was defined as <140/90 mmHg [19]. We extracted the blood pressure data from the Residence Health Record System, which recorded SBP and DBP values measured in the annual health examinations and regular follow-ups of the NEPHSP participants.

Statistical Analysis

Baseline outcomes of the participants were statistically described. Based on the baseline outcomes, we used a longitudinal study design to evaluated effect of the NEPHSP on blood pressure control via testing the blood pressure outcomes that were repetitively measured during the regular follow-ups that were quarterly performed in 2023.

We fit generalized estimating equations (GEE) models to analyze the repetitively measured blood pressure data that contained a continuous time variable [20]. GEE was capable of

analyzing numerical and categorical data that are repetitively measured [20]. Both level and slope of the blood pressure outcome changes were analyzed. To analyze the level and slope of the blood pressure outcome changes, the time variables were set as categorical and continuous variables respectively. The analysis was conducted with two-side tests at the 5% level of significance.

The following participant characteristics were adjusted as covariates: age, gender, body mass index, waist circumference, exercise engagement, alcohol drinking and smoking status, fasting plasma glucose, total cholesterol, triglyceride, low density lipoprotein, high density lipoprotein, baseline SBP and DBP values, diagnosis of cardiovascular and renal diseases, duration of hypertension diagnosis.

Sensitivity and Stratified Analyses

A series of stratified and sensitivity analyses were conducted to identify whether the blood pressure outcome changes were differed by subgroups. The subgroups were predefined as older age group (more than 64 years old) and younger age group (less than 65 years old), male group and female group, CVD diagnosis group and no CVD diagnosis group, baseline controlled SBP group and baseline uncontrolled SBP group. We fit GEE models to assess the changes in blood pressure outcomes separately for those subgroups. We then tested the interactive effects between the time variables (continuous time variable) and the subgroup indicators using the total sample to formally evaluate whether the blood pressure outcome changes differed between the subgroups.

Ethical Considerations

The study was conducted in accordance with the Declaration of Helsinki and approved by the Committee on Human Research of the Jining NO.1 People's Hospital (2023 Ethical Approval No. KYLL-202309-176). The need for informed consent was waived due to the retrospective nature of this study.

Results

Baseline outcomes

The baseline outcomes were accessible in Table 1. A total of 516777 participants were involved in this study. The mean (SD) age was 68.39 (9.57) years, 58.46% were female. 66.94% of the participants were over 65 years old. The mean (SD) values of baseline SBP and DBP were 147.12(19.88) mm/Hg and 85.11(11.79) mm/Hg respectively. The mean values of baseline SBP was above the normal criteria [19]. The control rates of baseline SBP and DBP were 39.79% and 69.21% respectively.

Changes in SBP control

The changes in SBP control were described in Figure 2. SBP mean values of the NEPHSP participants showed a decreased trend (-1.85, 95% CI, -0.186 to -0.184, P<0.001). Compared with the baseline SBP mean value, SBP mean value quarterly decreased by 5.06 mm Hg (95% CI, -5.11 to -5.00, P<0.001), 6.69 mm Hg (95% CI, -6.74 to -6.63, P<0.001), 10.30 mm Hg (95% CI, -10.34 to -10.23, P<0.001), 6.63 mm Hg (95% CI, -6.68 to -6.57, P<0.001).

SBP control rates of the NEPHSP participants showed an increased trend (0.185, 95% CI, 0.183 to 0.187, P<0.001) (Figure 2). Compared with the baseline SBP control rate, SBP control rates quarterly increased to 53.12% (0.60, 95% CI, 0.59 to 0.61, P<0.001), 56.61%

(0.76, 95% CI, 0.75 to 0.77, P<0.001), 63.40% (1.08, 95% CI, 1.07 to 1.09, P<0.001), 55.09% (0.69, 95% CI, 0.68 to 0.70, P<0.001).

Changes in DBP control

The changes in SBP control were described in Figure 3. DBP mean values of the NEPHSP participants showed a decreased trend (-0.77, 95% CI, -0.78 to -0.76, P<0.001). Compared with the baseline DBP mean value, DBP mean value quarterly decreased by 1.75 mm Hg (95% CI, -1.79 to -1.72, P<0.001), 2.64 mm Hg (95% CI, -2.68 to -2.61, P<0.001), 4.20 mm Hg (95% CI, -4.23 to -4.16, P<0.001), 2.64 mm Hg (95% CI, -2.68 to -2.61, P<0.001). DBP control rates of the NEPHSP participants showed an increased trend (0.169, 95% CI, 0.166 to 0.171, P<0.001) (Figure 2). Compared with the baseline DBP control rate, DBP control rates quarterly increased to 78.11% (0.52, 95% CI, 0.51 to 0.53, P<0.001), 80.32% (0.67, 95% CI, 0.66 to 0.68, P<0.001), 83.17% (0.89, 95% CI, 0.88 to 0.90, P<0.001), 79.47% (0.61, 95% CI, 0.60 to 0.62, P<0.001).

Sensitivity and Stratified Analyses

Our sensitivity analysis by the predefined subgroups showed that decrease of blood pressure mean values and increase of blood pressure control rates were consistent across subgroups of age, gender, diagnosis of baseline cardiovascular. The parameters of sensitivity analysis were accessible in Supplement 1. Subgroup analysis.

The changes in SBP outcomes were converse between baseline controlled SBP and uncontrolled SBP groups. The baseline controlled SBP group had an increase control of SBP mean values (1.09, 95% CI, 1.08 to 1.11, P<0.001), while the baseline uncontrolled SBP group had a decrease control of SBP mean values (-3.79, 95% CI, -3.81 to -3.78, P<0.001). The SBP control rates decreased in the baseline controlled SBP group (-0.335, 95% CI, -0.338 to -0.332, P<0.001), while the SBP control rates increased in the baseline

uncontrolled SBP group (0.487, 95% CI, 0.484 to 0.489, P<0.001).

The changes in SBP control of the age group were described in Figure 4. Compared with younger age group, older age group a larger decrease in SBP mean values (0.87, 95% CI, 0.85 to 0. 90, P<0.001) and a larger increase in SBP control rates (0.054, 95% CI, 0.051 to 0.058, P<0.001). The SBP mean values of the older age group were higher than the younger age group (1.00, 95% CI, 0.93 to 1.06, P<0.001). The SBP control rates of the older age group were significantly lower than the younger age group (-0.288, 95% CI, -0.297 to -0.279, P<0.001).

The changes in SBP control of the participants with and without CVD were described in Figure 5. The participants with CVD had smaller decrease in SBP mean values (-0.38, 95% CI, -0.41 to -0.35, P<0.001) and smaller increase in SBP control rates (-0.041, 95% CI, -0.045 to -0.037, P<0.001) than the blood pressures outcomes of participants without CVD. The SBP control rates of the participants with CVD were significantly lower than the participants without CVD (-0.044, 95% CI, -0.051 to -0.037, P<0.001).

The stratified analysis by gender demonstrated that larger decrease in SBP mean values (0.19, 95% CI, 0.16 to 0. 21, P<0.001) and larger increase in SBP control rates (0.016, 95% CI, 0.013 to 0. 020, P<0.001) were larger in female group than male group, while the differences were relatively small.

Discussion

With our knowledge, this is the first study that longitudinally explored effect of National Essential Public Health Service Package on blood pressure control. The study findings demonstrated that the NEPHSP was effective on improving SBP and DBP control. The NEPHSP decreased mean values of SBP and DBP, increased control rates of SBP and DBP.

The routine follow-up that monitored blood pressures and the individualized interventions of the NEPHSP might contribute to the improvement of SBP and DBP control. The routine follow-ups generated clinically crucial data that could recognize prioritization of the participant subgroups who had poorly controlled blood pressures [21]. Previous studies also reported that the regular population review that enabled formulation of customized interventions for improving blood pressure control is effective strategy on hypertension management [21-24]. According to the evaluations of routine follow-ups, individualized interventions were formulated to identify appropriate strategies to improve blood pressure control of participants with poorly controlled blood pressures [21,22,25].

Although the NEPHSP improved control of blood pressures, the mean values of SBP were still slightly higher to the normal criteria. This might be caused by therapeutic inertia [26]. Therapeutic inertia was defined as failure of healthcare professionals to initiate or intensify treatment appropriately during visits [26,27]. Previous research demonstrated that the failure to appropriately initiate or intensify treatment was introduced by perspective that healthcare professionals thought that near-target blood pressures were acceptable and overconcern about adverse effects caused by treatment intensification [28-31]. Because the doctor-related factors leading to therapeutic inertia, the participants with near-target blood pressures might not accept intensification of anti-hypertensive treatments, which could contribute to the slightly higher mean values of blood pressures [28-31]. Although the therapeutic inertia was associated with poor blood pressure control and cardiovascular events, therapeutic inertia is common in hypertension management in primary care settings [28,29,31]. Given this situation, interventions for handling therapeutic inertia are important for improving hypertension management in primary care settings [26,28,29,31]. However, in terms of the NEPHSP, no component for tackling therapeutic inertia were embedded. The relevant components can be considered to include in the NEPHSP [26].

The subgroup analysis showed that the older participants had more blood pressure outcomes improvement than the younger participants. This finding might be relevant to the referral mechanism of the NEPHSP. Compared with younger hypertensive patients, older hypertensive patients have more complex health conditions, such as frailty, comorbidities, and polypharmacy [32-39]. The complex health conditions can introduce challenges for blood pressure control in primary care settings, which are positively associated with poor blood pressure control [32-39]. To improve poor blood pressure control of older patients with complex health conditions in primary care settings, referral mechanism to superior medical institutions is important [33,35,37-40]. In terms of the NEPHSP, the older participants with complex health conditions and poor blood pressure control were recognized via the regular follow up evaluations. Based on the health condition evaluations of the regular follow ups, the older participants could accept more referral to superior medical institutions than the younger participants. Through the referral to superior medical institutions, the older participants could receive more intensive anti-hypertensive treatments than the treatments in primary care settings [33,35,37-40]. Because the intensive anti-hypertensive treatments provided in superior medical institutions, the older participants had more blood pressure control improvement than the younger participants [33,35,37-40].

Although the older participants had more blood pressure control improvement than the younger participants, the SBP mean values of the older participants were still higher than the younger participants. Moreover, the SBP control rates of the older participants were significantly lower than the younger participants. These study findings might be associated with concerns about adverse events caused by blood pressure lowering pharmacotherapy [32-39]. However, previous robust research evidence demonstrated that lowing blood pressures of older adults to normal range is safe and effective on reducing risks of cardiovascular events [41,42]. Consequently, older people with hypertension should have

similar blood pressure control manners to younger people with hypertension [41,42]. Given this situation, strategies to intensify blood pressure control of older participants engaging in the NEPHSP are necessary [41,42].

The blood pressure control improvement of the participants with CVD were less than the participants without CVD, while blood pressure control of people comorbid hypertension with CVD need to be more intensive than hypertensive people without CVD [42]. Similar to the older participants, the hypertensive participants comorbid with CVD also demanded more referral to superior medical institutions for achieving optimal blood pressure control [43-48]. Compared with hypertensive patients without CVD, the patients with CVD demand more intensive blood pressure control to prevent cardiovascular events, while blood pressure control of hypertensive patients with CVD are challenging in primary care settings [43-48]. The main challenges are potential adverse drug effects caused by polypharmacy and emergent cardiovascular events caused by intensive anti-hypertensive treatments [43-48]. Given this situation, referral to superior medical institutions is necessary for hypertensive patients with CVD to achieve optimal blood pressure control via providing intensive and safe anti-hypertensive treatments [43-48]. Although the NEPHSP had the algorithm to evaluate health conditions of the participants with comorbidities and subsequent referral mechanism to superior medical settings, the blood pressure control improvement of the participants with CVD were still less than the participants without CVD. The less blood pressure control improvement of the participants with CVD could be caused by health condition evaluation of the regular follow-ups. The health condition evaluations might fail to accurately assess health conditions of the participants with CVD as the evaluations did not have systematic tools such as checklists, which could lead to failure to refer the participants who needed referral [43-48]. Furthermore, no explicit criteria for referral of participants with CVD were pre-defined, which could lead to confusion for the

primary healthcare professionals to make the decisions on referral [43-48]. Given blood pressure control of people comorbid hypertension with CVD need to be more intensive than hypertensive people without CVD, strategies for intensifying blood pressure control of the NEPHSP participants with CVD should be considered [43-48].

The subgroup analysis showed that the participants with controlled SBP at baseline had an increase in SBP mean values and a decrease in SBP control rates, which were converse to the SBP results of all study participants. The converse results could be associated with the health evaluation algorithm of the regular follow-ups of the NEPHSP. According to the health evaluation algorithm, the participants who had controlled blood pressures evaluated in the regular follow-ups would accept no specific interventions. Because no specific interventions were provided, the participants with controlled SBP at baseline could have an increase in SBP mean values and a decrease in SBP control rates. Although SBP of the participants were controlled at baseline, the increase of SBP mean values within the normal range could also increase CVD events [49]. Given this situation, the health evaluation algorithm and interventions of the NEPHSP for the participants with controlled SBP at baseline were suggested to re-formulate [49-53].

This study had several limitations. Although the effects of the NEPHSP on blood pressure control was modest, this study could not confirm the factors impacting blood pressure control of the NEPHSP.

The group divisions for subgroup analysis were not explicit and general. Further studies that included gradient group division to explore factors impacting hypertension control of NEPHSP were needed. Randomization for group division was not applied in subgroup analysis, which could lead to uneven distribution of confounding factors. Further studies that used randomization or matched group division were need to confirm the factors impacting hypertension control of NEPHSP. This study merely explored baseline

characteristics that could impact hypertension control of NEPHSP, future studies exploring impact of trajectories of the factors on hypertension control of NEPHSP were needed. This study merely evaluated NEPHSP in a pilot city, further national wide studies were needed.

Conclusion

The NEPHSP was effective on improving blood pressure control of Chinese people with hypertension. However, SBP mean values of the study participants were near-target, which could imply therapy inertia of the NEPHSP. Strategies to tackle potential therapy inertia were suggested to perform for intensifying blood pressure control of the NEPHSP. The effects of the NEPHSP on blood pressure control of older participants and participants with CVD were modest. Intensive treatment modules were suggested to embed into the NEPHSP for improving blood pressure control of older participants and participants with CVD.

Further studies confirming effects of the NEPHSP on blood pressure control of people with specific characteristics, such as older age and comorbidities, are required.

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Declarations

No funding was received to assist with the preparation of this manuscript. The authors have no competing interests to declare that are relevant to the content of this article.

Data availability

The data that support the findings of this study are available on reasonable request from the corresponding author. The data are not publicly available due to their containing information that could compromise the privacy of the participants.

References

1. Christopher JM, Cristiana A, Kaja MA, Mohammad A, Mohsen AK, Foad AA, et al. Five insights from the Global Burden of Disease Study 2019. Lancet. 2020;396(10258):1135-1159. doi:10.1016/S0140-6736(20)31404-5. PMID:33069324; PMCID:PMC7116361.

2. Theo V, Stephen SL, Cristiana A, Kaja MA, Mohammad A, Mitra A, et al. Global burden of 369 diseases and injuries in 204 countries and territories, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. Lancet. 2020;396(10258):1204-1222. doi:10.1016/S0140-6736(20)30925-9. PMID:33069326. PMCID:PMC7567026.

3. Lewington S, Lacey B, Clarke R, Guo Y, Kong XL, Yang L, et al. China Kadoorie Biobank Consortium. The Burden of Hypertension and Associated Risk for Cardiovascular Mortality in China. JAMA Intern Med. 2016;176(4):524-32. doi:10.1001/jamainternmed.2016.0190. PMID:26975032.

4. Christopher JM, Aleksandr YA, Peng Z, Cristiana A, Kaja MA, Mohsen AK, et al. Global burden of 87 risk factors in 204 countries and territories, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. Lancet. 2020;396(10258):1223-1249. doi:10.1016/S0140-6736(20)30752-2. PMID:33069327. PMCID:PMC7566194.

5. Roth GA, Mensah GA, Johnson CO, Addolorato G, Ammirati E, Baddour LM, et al. Global burden of chronic respiratory diseases and risk factors, 1990-2019: an update from the Global Burden of Disease Study 2019. EClinicalMedicine. 2023;59:101936. doi:10.1016/j.eclinm.2023.101936. PMID:37229504. PMCID:PMC7614570.

6. Yang ZJ, Liu J, Ge JP, Chen L, Zhao ZG, Yang WY. China National Diabetes and Metabolic Disorders Study Group. Prevalence of cardiovascular disease risk factor in the Chinese population: the 2007-2008 China National Diabetes and Metabolic Disorders Study. Eur Heart J. 2012;33(2):213-220. doi:10.1093/eurheartj/ehr205. PMID:21719451.

7. Li D, Lv J, Liu F, Liu P, Yang X, Feng Y, et al. Hypertension burden and control in

mainland China: Analysis of nationwide data 2003-2012. Int J Cardiol. 2015;184:637-644. doi:10.1016/j.ijcard.2015.03.045. PMID:25771229.

8. Feng XL, Pang M, Beard J. Health system strengthening and hypertension awareness, treatment and control: data from the China Health and Retirement Longitudinal Study. Bull World Health Organ. 2014;92(1):29-41. doi:10.2471/BLT.13.124495. PMID:24391298. PMCID:PMC3865551.

9. He J, Gu D, Chen J, Wu X, Kelly TN, Huang JF, et al. Premature deaths attributable to blood pressure in China: a prospective cohort study. Lancet. 2009;374(9703):1765-1772. doi:10.1016/S0140-6736(09)61199-5. PMID: 19811816.

10. Yang G, Wang Y, Zeng Y, Gao GF, Liang X, Zhou M, et al. Rapid health transition in China, 1990-2010: findings from the Global Burden of Disease Study 2010. Lancet. 2013;381(9882):1987-2015. doi:10.1016/S0140-6736(13)61097-1. PMID:23746901. PMCID:PMC7159289.

11. Wang J, Zhang L, Wang F, Liu L, Wang H. China National Survey of Chronic Kidney Disease Working Group. Prevalence, awareness, treatment, and control of hypertension in China: results from a national survey. Am J Hypertens. 2014;27(11):1355-61. doi:10.1093/ajh/hpu053. PMID: 24698853. PMCID: PMC4263934.

12. Li W, Gu H, Teo KK, Bo J, Wang Y, Yang J, et al. PURE China Investigators. Hypertension prevalence, awareness, treatment, and control in 115 rural and urban communities involving 47000 people from China. J Hypertens. 2016;34(1):39-46. doi:10.1097/HJH.0000000000000745. PMID:26630211.

13. Lu J, Lu Y, Wang X, Li X, Linderman GC, Wu C, 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(10112):2549-2558. doi:10.1016/S0140-6736(17)32478-9. doi:10.1016/S0140-

6736(17)32897-0. PMID: 29102084.

14. You, L., Zhao, J., Chen, X. National Essential Public Health Services Programs over the Past Decade Research Report Two：Progress and Achievements of the Implementation of National Essential Public Health Services Programs over the Past Decade. Chinese General Practice. 2022;25:3209-3220. https://doi.org/10.12114/j.issn.1007-9572.2022.0407.

15. Fang G, Yang D, Wang L, Wang Z, Liang Y, Yang J. Experiences and Challenges of Implementing Universal Health Coverage With China's National Basic Public Health Service Program: Literature Review, Regression Analysis, and Insider Interviews. JMIR Public Health Surveill. 2022;8(7):e31289. doi:10.2196/31289. PMID: 35867386. PMCID: PMC9356336.

16. Li X, Lu J, Hu S, Cheng KK, De Maeseneer J, Meng Q, et al. The primary health-care system in China. Lancet. 2017;390(10112):2584-2594. doi:10.1016/S0140-6736(17)33109-4. PMID: 29231837.

17. Li X, Krumholz HM, Yip W, Cheng KK, De Maeseneer J, Meng Q, et al. Quality of primary health care in China: challenges and recommendations. Lancet. 2020;395(10239):1802-1812. doi:10.1016/S0140-6736(20)30122-7. PMID: 32505251. PMCID: PMC7272159.

18. Xiong S, Jiang W, Meng R, Hu C, Liao H, Wang Y, et al. Factors associated with the uptake of national essential public health service package for hypertension and type-2 diabetes management in China's primary health care system: a mixed-methods study. Lancet Reg Health West Pac. 2022;31:100664. doi:10.1016/j.lanwpc.2022.100664. PMID:36879777. PMCID:PMC9985050.

19. James PA, Oparil S, Carter BL, Cushman WC, Dennison-Himmelfarb C, Handler J, et al. 2014 evidence-based guideline for the management of high blood pressure in adults: report from the panel members appointed to the Eighth Joint National Committee (JNC 8).

JAMA. 2014;311(5):507-20. doi:10.1001/jama.2013.284427. PMID: 24352797.

20. Huang Y, Pan J. Penalized joint generalized estimating equations for longitudinal binary data. Biom J. 2022;64(1):57-73. doi:10.1002/bimj.202000336. PMID: 34587284.

21. Glynn LG, Murphy AW, Smith SM, Schroeder K, Fahey T. Interventions used to improve control of blood pressure in patients with hypertension. Cochrane Database Syst Rev. 2010;17(3):CD005182. doi:10.1002/14651858.CD005182.pub4. PMID: 20238338.

22. Jaffe MG, Lee GA, Young JD, Sidney S, Go AS. Improved blood pressure control associated with a large-scale hypertension program. JAMA. 2013;310(7):699-705. doi:10.1001/jama.2013.108769. PMID:23989679. PMCID: PMC4270203.

23. Jafar TH, Gandhi M, de Silva HA, Jehan I, Naheed A, Finkelstein EA, et al. COBRA-BPS Study Group. A Community-Based Intervention for Managing Hypertension in Rural South Asia. N Engl J Med. 2020;382(8):717-726. doi:10.1056/NEJMoa1911965. PMID:32074419.

24. Schwalm JD, McCready T, Lopez-Jaramillo P, Yusoff K, Attaran A, Lamelas P, et al. A community-based comprehensive intervention to reduce cardiovascular risk in hypertension (HOPE 4): a cluster-randomised controlled trial. Lancet. 2019;394(10205):1231-1242. doi:10.1016/S0140-6736(19)31949-X. PMID:31488369.

25. Anand TN, Joseph LM, Geetha AV, Prabhakaran D, Jeemon P. Task sharing with non-physician health-care workers for management of blood pressure in low-income and middle-income countries: a systematic review and meta-analysis. Lancet Glob Health. 2019;7(6):e761-e771. doi:10.1016/S2214-109X(19)30077-4. doi:10.1016/S2214-109X(19)30367-5. PMID: 31097278. PMCID: PMC6527522.

26. Schlaich MP, Kiuchi MG, Nolde JM, Lugo-Gavidia LM, Carnagarin R. Therapeutic inertia in hypertension management - status quo in primary care. J Hypertens. 2021 Jun;39(6):1107-1108. doi: 10.1097/HJH.0000000000002830. PMID:33967214.

27. Phillips LS, Branch WT, Cook CB, Doyle JP, El-Kebbi IM, Gallina DL, et al. Clinical inertia. Ann Intern Med. 2001;135(9):825-34. doi:10.7326/0003-4819-135-9-200111060-00012. PMID:11694107.

28. Milman T, Joundi RA, Alotaibi NM, Saposnik G. Clinical inertia in the pharmacological management of hypertension: A systematic review and meta-analysis. Medicine (Baltimore). 2018;97(25):e11121. doi:10.1097/MD.0000000000011121. PMID:29924011. PMCID:PMC6025046.

29. Lebeau JP, Cadwallader JS, Vaillant-Roussel H, Pouchain D, Yaouanc V, Aubin-Auger I, et al. General practitioners' justifications for therapeutic inertia in cardiovascular prevention: an empirically grounded typology. BMJ Open. 2016;6(5):e010639. doi:10.1136/bmjopen-2015-010639. PMID:27178974. PMCID:PMC4874143.

30. Kerr EA, Zikmund-Fisher BJ, Klamerus ML, Subramanian U, Hogan MM, Hofer TP. The role of clinical uncertainty in treatment decisions for diabetic patients with uncontrolled blood pressure. Ann Intern Med. 2008;148(10):717-27. doi:10.7326/0003-4819-148-10-200805200-00004. PMID:18490685.

31. Schlaich MP, Kiuchi MG, Nolde JM, Lugo-Gavidia LM, Carnagarin R. Therapeutic inertia in hypertension management - status quo in primary care. J Hypertens. 2021;39(6):1107-1108. doi:10.1097/HJH.0000000000002830. PMID 33967214.

32. Masoli JAH, Delgado J, Pilling L, Strain D, Melzer D. Blood pressure in frail older adults: associations with cardiovascular outcomes and all-cause mortality. Age Ageing. 2020;49(5):807-813. doi:10.1093/ageing/afaa028. PMID:32133525. PMCID: PMC7444671.

33. Boyd C, Smith CD, Masoudi FA, Blaum CS, Dodson JA, Green AR, et al. Decision Making for Older Adults With Multiple Chronic Conditions: Executive Summary for the American Geriatrics Society Guiding Principles on the Care of Older Adults With Multimorbidity. J Am Geriatr Soc. 2019;67(4):665-673. doi:10.1111/jgs.15809.

PMID:30663782.

34. Anker D, Santos-Eggimann B, Zwahlen M, Santschi V, Rodondi N, Wolfson C, et al. Blood pressure in relation to frailty in older adults: A population-based study. J Clin Hypertens (Greenwich). 2019;21(12):1895-1904. doi:10.1111/jch.13722. PMID:31661601. PMCID:PMC8030340.

35. Benetos A, Petrovic M, Strandberg T. Hypertension Management in Older and Frail Older Patients. Circ Res. 2019;124(7):1045-1060. doi:10.1161/CIRCRESAHA.118.313236. PMID:30920928.

36. Masoli JAH, Mensah E, Rajkumar C. Age and ageing cardiovascular collection: blood pressure, coronary heart disease and heart failure. Age Ageing. 2022;51(8):afac179. doi:10.1093/ageing/afac179. PMID:35934320.

37. Bowling CB, Lee A, Williamson JD. Blood Pressure Control Among Older Adults With Hypertension: Narrative Review and Introduction of a Framework for Improving Care. Am J Hypertens. 2021;34(3):258-266. doi:10.1093/ajh/hpab002. PMID:33821943. PMCID:PMC8022931.

38. Anker D, Santos-Eggimann B, Zwahlen M, Santschi V, Rodondi N, Wolfson C, et al. Blood pressure control and complex health conditions in older adults: impact of recent hypertension management guidelines. J Hum Hypertens. 2021;35(3):280-289. doi:10.1038/s41371-020-0334-4. PMID:32346124.

39. Benetos A, Petrovic M, Strandberg T. Hypertension Management in Older and Frail Older Patients. Circ Res. 2019;124(7):1045-1060. doi:10.1161/CIRCRESAHA.118.313236. PMID:30920928.

40. Zhang WL, Cai J. STEP to blood pressure management of elderly hypertension: evidence from Asia. Hypertens Res. 2022;45(4):576-582. doi:10.1038/s41440-022-00875-7. PMID: 35277670. PMCID: PMC8923999.

41. Kazem R, Zeinab B, Milad N, Emma C, Dexter C, Malgorzata W, et al. Age-stratified and blood-pressure-stratified effects of blood-pressure-lowering pharmacotherapy for the prevention of cardiovascular disease and death: an individual participant-level data meta-analysis. Lancet. 2021;398(10305):1053-1064. doi:10.1016/S0140-6736(21)01921-8. PMID:34461040. PMCID: PMC8473559.

42. Curfman G, Bauchner H, Greenland P. Treatment and Control of Hypertension in 2020: The Need for Substantial Improvement. JAMA. 2020;324(12):1166-1167. doi:10.1001/jama.2020.13322. PMID:32902571.

43. Boyd CM, Darer J, Boult C, Fried LP, Boult L, Wu AW. Clinical practice guidelines and quality of care for older patients with multiple comorbid diseases: implications for pay for performance. JAMA. 2005;294(6):716-24. doi:10.1001/jama.294.6.716. PMID:16091574.

44. Valderas JM, Starfield B, Roland M. Multimorbidity's many challenges: A research priority in the UK. BMJ. 2007;334(7604):1128. doi:10.1136/bmj.39226.427095.3A. PMID:17540918. PMCID:PMC1885310.

45. Kennard L, O'Shaughnessy KM. Treating hypertension in patients with medical comorbidities. BMJ. 2016;352:i101. doi:10.1136/bmj.i101. PMID:26884124.

46. Sarkar C, Dodhia H, Crompton J, Schofield P, White P, Millett C, et al. Hypertension: a cross-sectional study of the role of multimorbidity in blood pressure control. BMC Fam Pract. 2015;16:98. doi:10.1186/s12875-015-0313-y. PMID:26248616. PMCID:PMC4528716.

47. Paulsen MS, Andersen M, Thomsen JL, Schroll H, Larsen PV, Lykkegaard J, et al. Multimorbidity and blood pressure control in 37 651 hypertensive patients from Danish general practice. J Am Heart Assoc. 2012;2(1):e004531. doi:10.1161/JAHA.112.004531. PMID:23525411. PMCID:PMC3603256.

48. Wong MC, Wang HH, Cheung CS, Tong EL, Sek AC, Cheung NT, et al. Factors

associated with multimorbidity and its link with poor blood pressure control among 223,286 hypertensive patients. Int J Cardiol. 2014;177(1):202-8. doi: 10.1016/j.ijcard.2014.09.021. PMID: 25499379.

49. Messerli FH, Hofstetter L, Rimoldi SF, Rexhaj E, Bangalore S. Risk Factor Variability and Cardiovascular Outcome: JACC Review Topic of the Week. J Am Coll Cardiol. 2019;73(20):2596-2603. doi:10.1016/j.jacc.2019.02.063. PMID:31118154.

50. Mehlum MH, Liestøl K, Kjeldsen SE, Julius S, Hua TA, Rothwell PM, et al. Blood pressure variability and risk of cardiovascular events and death in patients with hypertension and different baseline risks. Eur Heart J. 2018;39(24):2243-2251. doi:10.1093/eurheartj/ehx760. PMID:29365085.

51. Mehlum MH, Liestøl K, Kjeldsen SE, Julius S, Hua TA, Rothwell PM, et al. Blood pressure variability and risk of cardiovascular events and death in patients with hypertension and different baseline risks. Eur Heart J. 2018;39(24):2243-2251. doi:10.1093/eurheartj/ehx760. PMID:29365085.

52. Mezue K, Goyal A, Pressman GS, Matthew R, Horrow JC, Rangaswami J. Blood pressure variability predicts adverse events and cardiovascular outcomes in SPRINT. J Clin Hypertens (Greenwich). 2018;20(9):1247-1252. doi:10.1111/jch.13346. PMID:29984884. PMCID:PMC8031192.

53. Stevens SL, Wood S, Koshiaris C, Law K, Glasziou P, Stevens RJ, et al. Blood pressure variability and cardiovascular disease: systematic review and meta-analysis. BMJ. 2016;354:i4098. doi:10.1136/bmj.i4098. PMID:27511067. PMCID: PMC4979357.

Abbreviations

CVD: cardiovascular diseases

NEPHSP: National Essential Public Health Service Package

SBP: systolic blood pressure

DBP: diastolic blood pressure

GEE: generalized estimating equations

Supplementary Files

Figures

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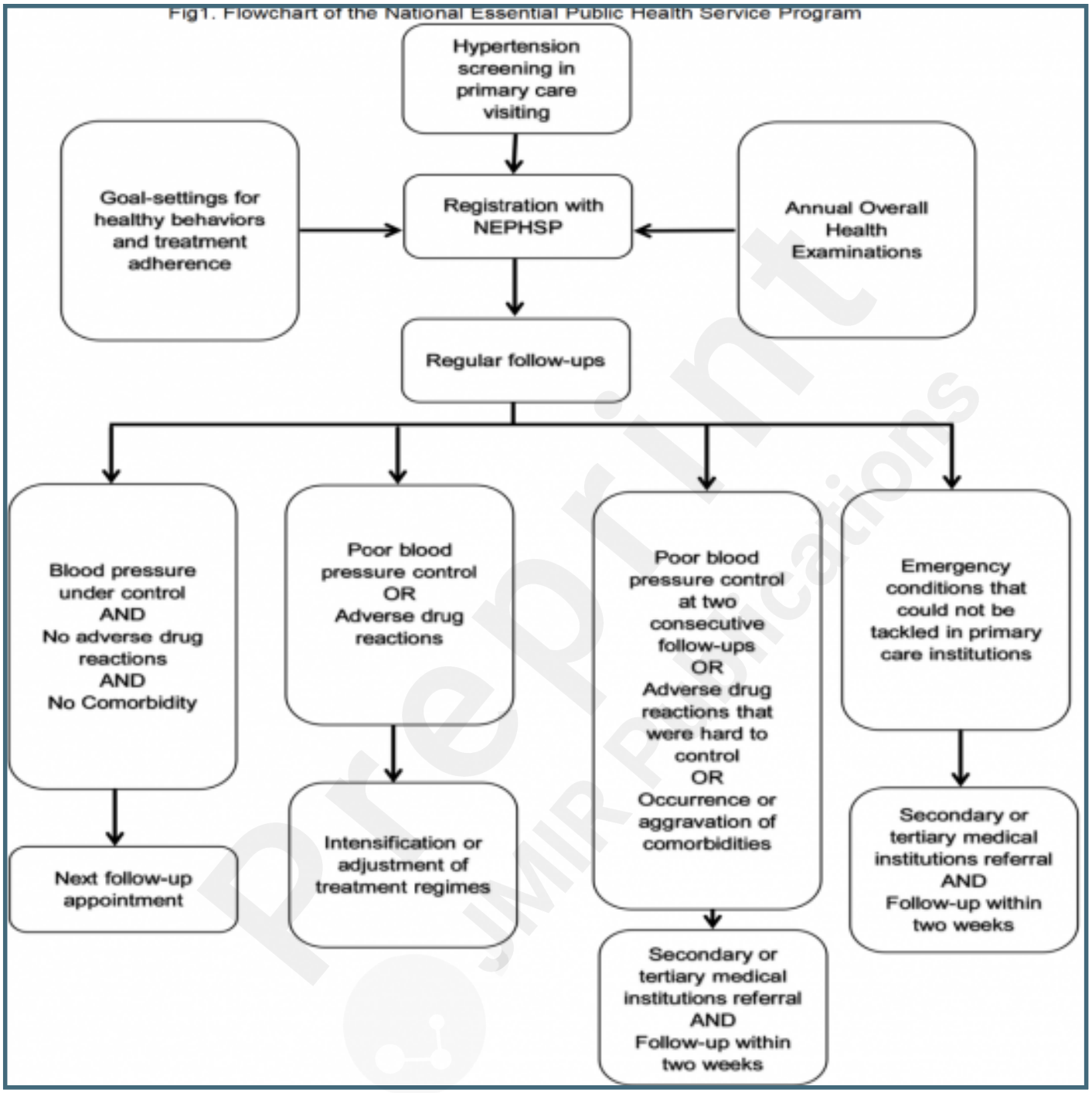
Fig1. Flowchart of the National Essential Public Health Service Program
Hypertension screening in primary care visiting
Goal-settings for healthy behaviors and treatment adherence
Registration with NEPHSP
Annual Overall Health Examinations
Regular follow-ups
Blood pressure under control AND No adverse drug reactions AND No Comorbidity
Poor blood pressure control OR Adverse drug reactions
Poor blood pressure control at two consecutive follow-ups OR Adverse drug reactions that were hard to control OR Occurrence or aggravation of comorbidities
Emergency conditions that could not be tackled in primary care institutions
Next follow-up appointment
Intensification or adjustment of treatment regimes
Secondary or tertiary medical institutions referral AND Follow-up within two weeks
Secondary or tertiary medical institutions referral AND Follow-up within two weeks

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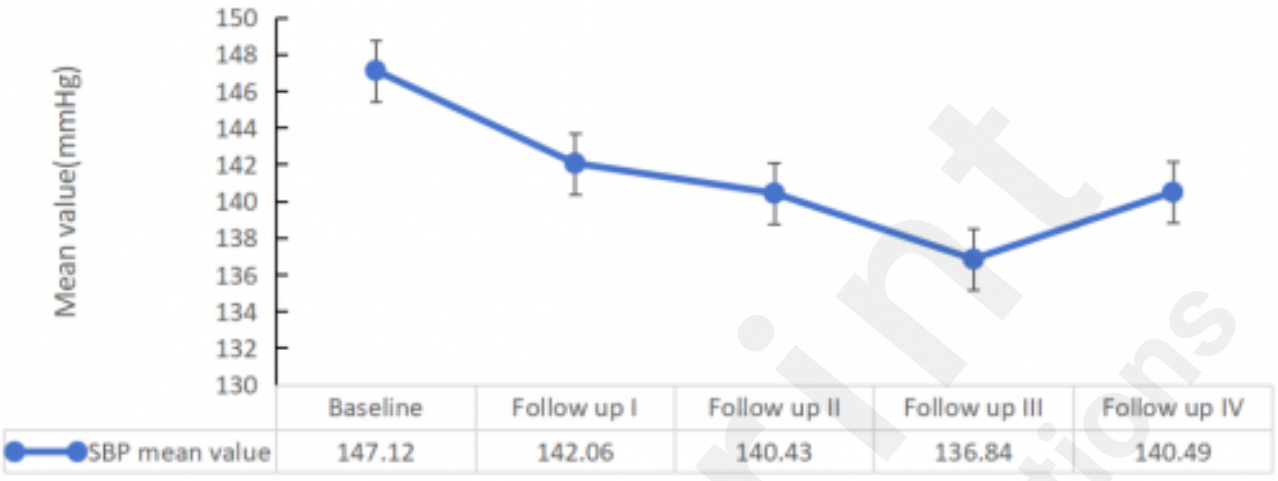
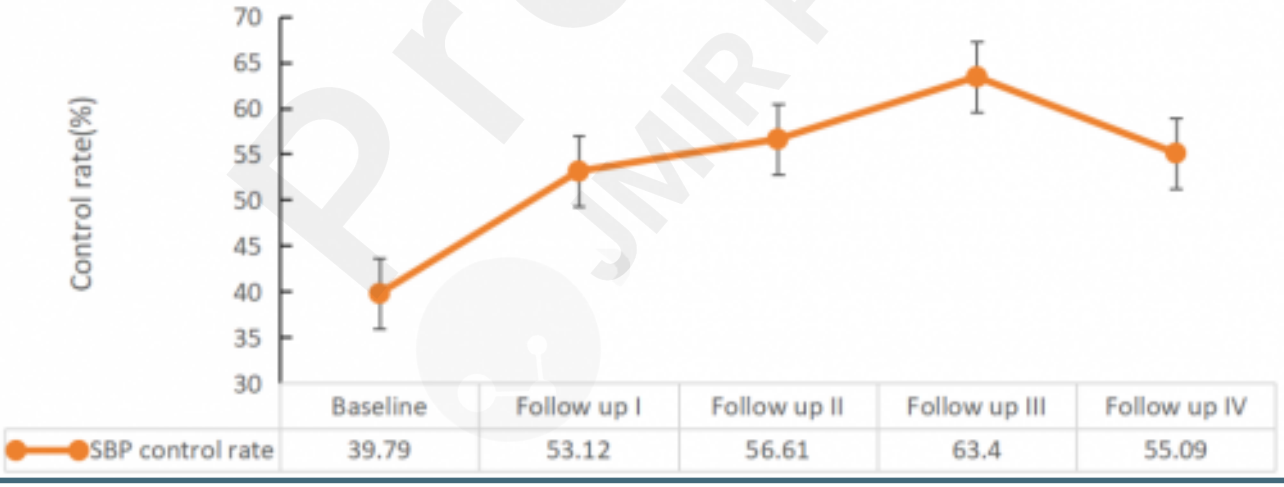
Figure 2. Changes in Systolic Blood Pressure Control



	Baseline	Follow up I	Follow up II	Follow up III	Follow up IV
SBP mean value	147.12	142.06	140.43	136.84	140.49



	Baseline	Follow up I	Follow up II	Follow up III	Follow up IV
SBP control rate	39.79	53.12	56.61	63.4	55.09

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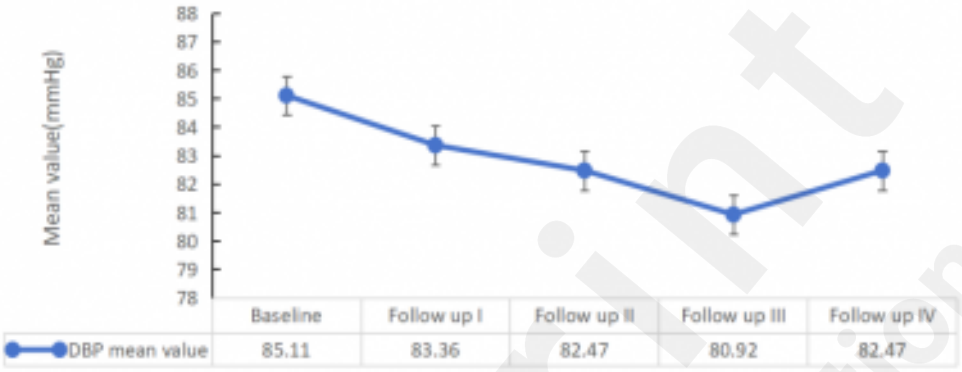
Figure3. Changes in Diastolic Blood Pressure Control



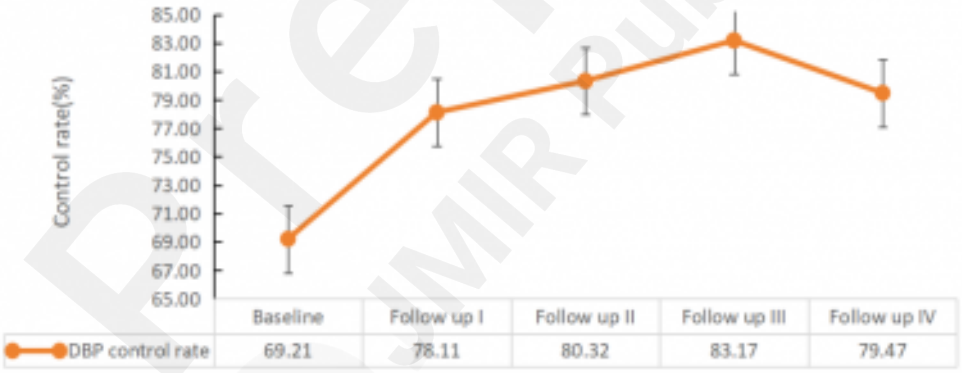


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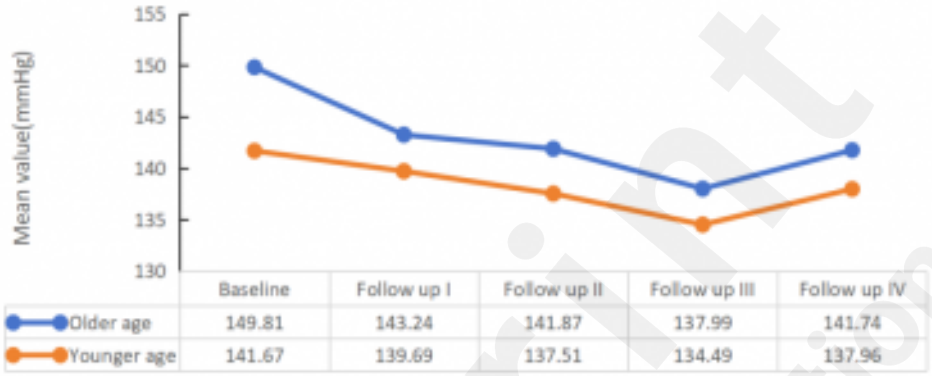
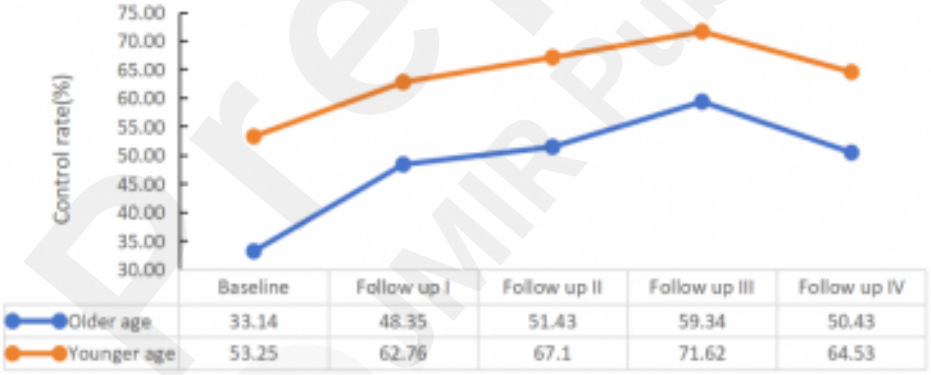
Figure 4. Systolic Blood Pressure Control of age groups



	Baseline	Follow up I	Follow up II	Follow up III	Follow up IV
Older age	149.81	143.24	141.87	137.99	141.74
Younger age	141.67	139.69	137.51	134.49	137.96



	Baseline	Follow up I	Follow up II	Follow up III	Follow up IV
Older age	33.14	48.35	51.43	59.34	50.43
Younger age	53.25	62.76	67.1	71.62	64.53

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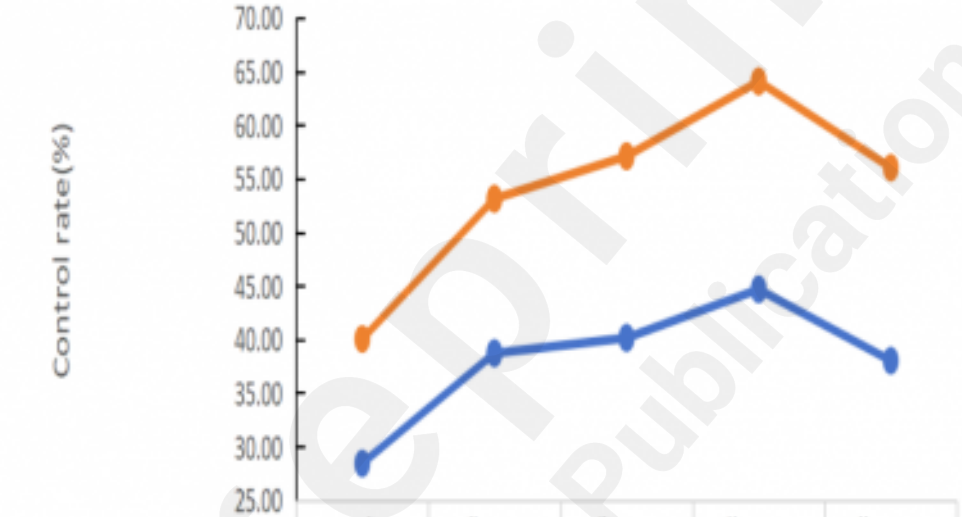
Figure 4. Systolic Blood Pressure Control of Cardiovascular disease group



	Baseline	Follow up I	Follow up II	Follow up III	Follow up IV
Cardiovascular group	28.42	38.7	40.13	44.66	38.01
Non-Cardiovascular group	40.03	53.11	57.08	64.06	56.01

Multimedia Appendixes

Untitled.
URL: http://asset.jmir.pub/assets/2c9ac77d7e2f713c7a109c05b57a4a91.docx