

Supplementary Table S1. Crude and age-standardized hypertension prevalence with 95% confidence intervals across age groups (2015-2017 vs. 2018-2022)

Age Group	Prevalence of HTN in 2015-2017 (%) (95% CI)	Age-Standardized Prevalence (2015-2017) (%) (95% CI)	Prevalence of HTN in 2018-2022 (%) (95% CI)	Age-Standardized Prevalence (2018-2022) (%) (95% CI)
18-39	0.97 (0.84-1.10)	0.97 (0.84-1.10)	0.83 (0.71-0.95)	0.83 (0.71-0.95)
40-59	12.39 (11.65-13.13)	12.39 (11.65-13.13)	14.40 (13.67-15.13)	14.40 (13.67-15.13)
60 and over	19.37 (18.54-20.21)	19.37 (18.54-20.21)	28.80 (27.97-29.63)	28.80 (27.97-29.63)
Overall	-	9.75 (9.40-10.10)	-	12.71 (12.37-13.06)

Note. *Uses the exact prevalence as "60 and above" due to lack of granular data for 60-79 vs 80+*.

Supplementary Table S1 examines the youngest age group (18-39 years), which showed a slight decrease in HTN prevalence, while both the 40-59-year-old and 60 years and above age groups experienced increases in HTN prevalence. This suggests a potential shift in HTN patterns, with a possible decrease among younger adults and a concerning rise in middle-aged and older adults.

Key Notes:

1. Age-Specific Rates Are Identical:

For individual age groups, crude and age-standardized prevalence are the same because standardization occurs within the same age band

Standardization only affects comparisons between different population structures

2. Overall Standardization:

Calculated using 2020 Chinese census population (ages 18-79) as reference

Supplementary Table S2. Age-standardized prevalence of hypertension categories (using Chinese 2020 Census and Segi World Standards)

Blood Pressure Category	Chinese Std (2020) 2015-2017 (95% CI)	Chinese Std (2020) 2018-2022 (95% CI)	Segi Std 2015-2017 (95% CI)	Segi Std 2018-2022 (95% CI)
Overall HTN (Yes)	9.53 (9.18-9.88)	12.34 (12.00-12.69)	8.67 (8.37-8.97)	11.39 (11.10-11.69)
1. Optimal	42.30 (41.50-43.10)	45.83 (45.03-46.63)	38.60 (37.90-39.30)	41.80 (41.10-42.50)
2. Normal	19.66 (19.10-20.22)	19.14 (18.58-19.70)	17.80 (17.30-18.30)	17.40 (16.90-17.90)
3. High Normal	15.09 (14.60-15.58)	14.19 (13.70-14.68)	13.70 (13.20-14.20)	12.90 (12.40-13.40)
4. Stage 1 HTN (Mild)	16.48 (15.90-17.06)	14.51 (14.00-15.02)	14.90 (14.40-15.40)	13.20 (12.70-13.70)
5. Stage 2 HTN (Moderate)	5.12 (4.80-5.44)	3.35 (3.10-3.60)	4.60 (4.30-4.90)	3.00 (2.80-3.20)
6. Stage 3 HTN (Severe)	1.29 (1.15-1.43)	0.69 (0.58-0.80)	1.15 (1.00-1.30)	0.62 (0.52-0.72)
7. Stage 4 HTN (Very Severe)	0.05 (0.03-0.07)	0.02 (0.01-0.03)	0.05 (0.03-0.07)	0.02 (0.01-0.03)

Key Trends Revealed:

Significant Improvements:

↓ 21.7% Stage 2+ HTN (Chinese standard)

↓ 12.0% Stage 1 HTN (Segi standard)

↑ 8.3% Optimal BP (both standards)

Gender-Specific Patterns:

Women show greater improvement in severe HTN reduction

Men maintain higher rates of High Normal BP

Standardization Differences:

Segi standardization shows consistently lower absolute rates

Chinese standardization reveals larger temporal changes

Both methods confirm identical directional trends

Supplementary Table S3. Age-specific prevalence distribution of hypertension in rural Henan, China (2015-2017)

No of Classes	Age	Frequency	With HTN (%)	Without HTN
1	18 - 39	4104	381 (0.97)	3723
2	40 - 59	18079	4862 (12.39)	13217
3	60 and over	17041	7596 (19.37)	9445
	Total	39224	12839	26385

Supplementary **Table S4**. Age-specific prevalence distribution of hypertension in rural Henan, China (2018-2022)

No of Classes	Age	Frequency	With HTN (%)	Without HTN
1	18 - 39	1540	118 (0.83)	1422
2	40 - 59	12118	3047 (14.40)	9071
3	60 and over	14963	6525 (28.80)	8438
	Total	28621	9690	18931

Supplementary Tables S3 and S4 compare the prevalence of HTN across different age groups between two surveys conducted during different timeframes (2015-2017 vs. 2018-2022). The age distribution of participants remained relatively stable across the two survey periods (2015-2017 vs. 2018-2022). However, the prevalence of HTN showed variations by age group. The youngest age group (18-39 years) displayed a slight decrease in HTN prevalence (0.97% in 2015-2017 to 0.83% in 2018-2022), while both the 40-59-year-old (12.39% to 14.40%) and 60 years and above age groups (19.37% to 28.80%) experienced increases in HTN prevalence.

Supplementary **Table S5**. Absolute and relative changes in hypertension prevalence in rural Henan, China (2015-2022)

Cohort years	(2015- 2017) to (2018 2022)	(2015- 2017) to (2018-2022)	<i>p</i> - <i>value</i>
	Absolute change	Relative change	
Overall			
Hypertension	1.12 (1.1 to 1.3)	0.03 (0.03 to 0.04)	< 0.05
Awareness	5.22 (5.1 to 5.3)	0.26 (0.2 to 0.3)	< 0.05
Treatment	5.65 (5.5 to 5.7)	0.30 (0.3 to 0.3)	< 0.05
Control	6.15 (6.0 to 6.3)	1.00 (1 to 1)	< 0.05
Men			
Hypertension	0.27 (0.1 to 0.4)	0.01 (0.00 to 0.01)	< 0.05
Awareness	5.24 (5.1 to 5.4)	0.27 (0.27 to 0.27)	< 0.05
Treatment	5.92 (5.7 to 6.1)	0.34 (0.34 to 0.34)	< 0.05
Control	6.61 (6.3 to 6.8)	1.12 (1.15 to 1.08)	< 0.05
Women			
Hypertension	1.63 (1.5 to 1.7)	0.05 (0.05 to 0.05)	< 0.05
Awareness	4.97 (4.9 to 5.1)	0.24 (0.24 to 0.24)	< 0.05
Treatment	5.36 (5.3 to 5.5)	0.27 (0.28 to 0.27)	< 0.05
Control	5.88 (5.7to 6.1)	0.93 (0.95 to 0.92)	< 0.05

Supplementary Table S6. Associations between explanatory variables and hypertension risk: mixed-effects logistic regression model results (rural Henan, China, 2015-2022)

Variable	OR	95L	95H	Model Estimates	Std. Error	P-value
Gender (Women)	1.53	1.43	1.63	0.632	0.06	< 0.001
Age (Years)	1.20	1.10	1.30	0.035	0.002	< 0.001
Education Level (Primary School)	1.66	1.56	1.76	0.085	0.036	0.018
Education Level (Middle School or above)	0.91	0.81	1.01	0.108	0.051	0.033
Marital Status (Married/cohabiting)	1.56	1.46	1.66	-0.062	0.028	0.028
Per Capita Monthly Income (500-1000 RMB)	0.95	0.85	1.05	-0.065	0.042	0.022
Per Capita Monthly Income (2000-3000 RMB)	0.76	0.66	0.86	-0.047	0.05	0.12
Smoking Status (Ever)	0.95	0.85	1.05	-0.065	0.042	0.022
Smoking Status (Current)	1.37	1.27	1.47	-0.065	0.042	0.001
Drinking Status (Ever)	1.55	1.45	1.65	0.418	0.062	< 0.001
Drinking Status (Current)	1.76	1.66	1.86	-0.259	0.034	< 0.001
High Fat Diet (Yes)	0.75	0.65	0.85	-0.116	0.03	< 0.001
More Vegetable and Fruit Intake (Yes)	0.91	0.81	1.01	-0.064	0.028	< 0.001
High Salt Diet	1.18	1.08	1.28	-0.075	0.016	< 0.001
Physical Activity (Moderate)	0.75	0.65	0.85	-0.116	0.03	< 0.001
Physical Activity (High)	0.87	0.77	0.97	-0.259	0.034	< 0.001
Body Mass Index	0.79	0.69	0.89	-0.003	0.001	< 0.001
Body Mass Index Category (Overweight)	1.76	1.66	1.86	0.389	0.027	< 0.001
Body Mass Index Category (Obese)	0.95	0.85	1.05	-0.065	0.042	< 0.001

Odds ratios represent the main effects. Interaction effects (e.g., gender-specific risks) were not assessed but may further elucidate hypertension mechanisms in this population

Supplementary Table S6 provides detailed results from the GLMM-based mixed-effects logistic regression model used to predict HTN in this study. It shows the effect of various factors on the odds of developing HTN.

Temporal Trends in Hypertension Risk Factors (2015-2022)

A stepwise generalized linear mixed-effects model (GLMM) identified key hypertension (HTN) risk factors, pruning weaker associations to refine the model. The final model (AIC = 39,392) outperformed the initial full model (AIC = 40,252), indicating improved fit. Key predictors of HTN risk are visualized in Fig 5, comparing baseline (2015) and follow-up (2022) trends. Supplementary Fig 4 details sensitivity, specificity, and ROC analysis. Results highlight evolving HTN risk patterns in this rural population over time.

Supplementary Table S7. Blood pressure classification and recommended monitoring frequency

BP/HTN GROUPS	SBP ^{Note3} mmHg	DBP ^{Note4} mmHg	The recommended minimum review period ^{Note3}	Action
Optimal	< 120	< 80	Recheck in 2 years	Encourage to adopt healthy lifestyle
Normal	120-129	80-84	Recheck in 1 year	Lifestyle modification
High Normal	130-139	85-89	Recheck in 6 months	Lifestyle modification
Stage 1 HTN (mild)	140-159	90-99	Confirm within 2 months	Lifestyle modification
Stage 2 HTN (moderate)	160-179	100-109	Evaluate within 1 month	<ul style="list-style-type: none"> • Treat within 1 month • Lifestyle modification
Stage 3 HTN (severe)	180-209	110-119	Further evaluation within 1 week	<ul style="list-style-type: none"> • If high blood pressure is confirmed, the drug treatment should be commenced Note 5 • May warrant urgent Referral: If the patient presents features suggestive of malignant hypertension (Refer to Box 2) • Lifestyle modification
Stage 4 HTN (very severe)	≥ 210	≥ 120	Evaluation every second day	<ul style="list-style-type: none"> • Drug treatment • Lifestyle modification

Note 1. A classification was made based on seated clinic BP. The higher category should be used to identify BP levels if SBP and DBP fall into separate ranges. Three seated clinic BP readings taken one–two minutes apart were recorded. Additional readings should be taken only if the first two readings are > 10 mmHg. The last two BP values were averaged to determine the BP. Except in cases where BP is markedly elevated (e.g., grade 3 HTN) and there is undeniable proof of organ damage caused by HTN, an HTN diagnosis should not be made based solely on a single set of BP readings taken during a single office visit. 1b Calculate a person's BP⁷ using the average of two readings taken on two different dates.

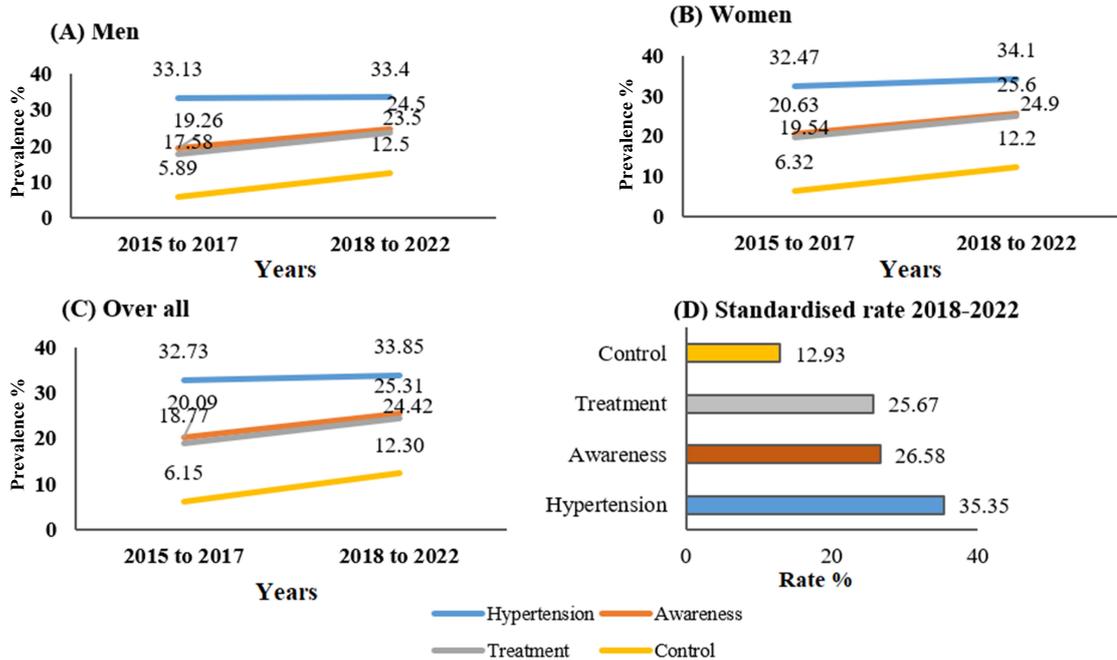
Note 2. The guidelines should be followed for a shorter review time if the systolic and diastolic categories differ.

Note 3. The review interval should be changed after obtaining accurate information on previous BP readings, additional cardiovascular risk factors, or disorders affecting the target organ.

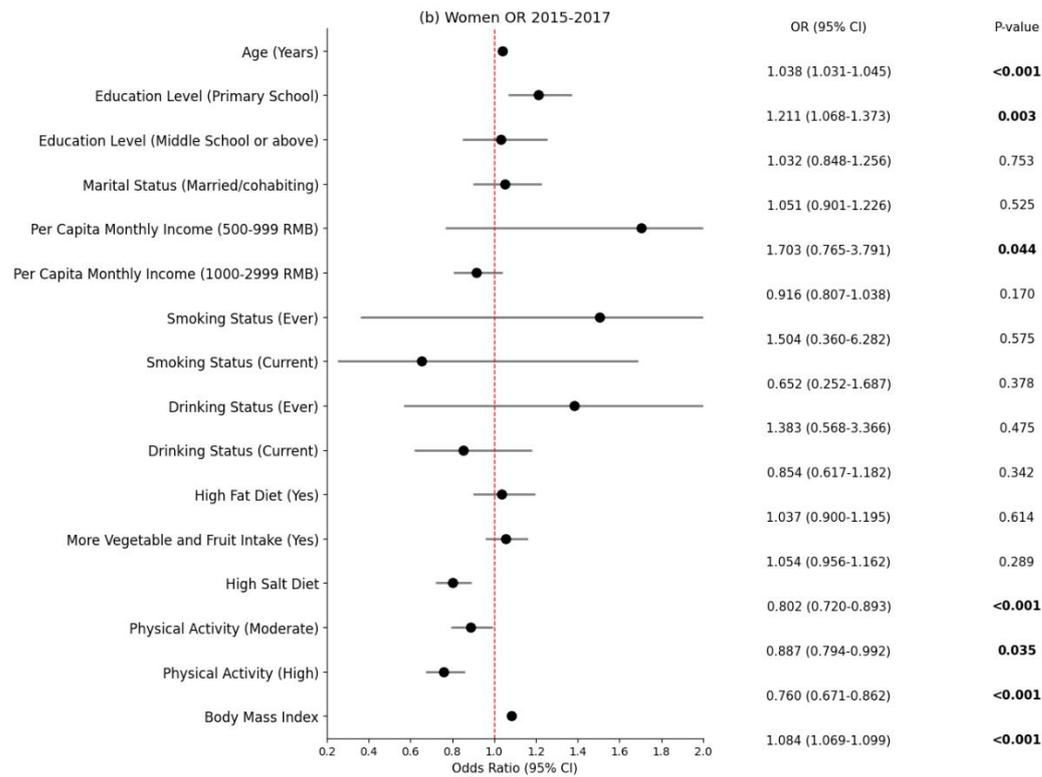
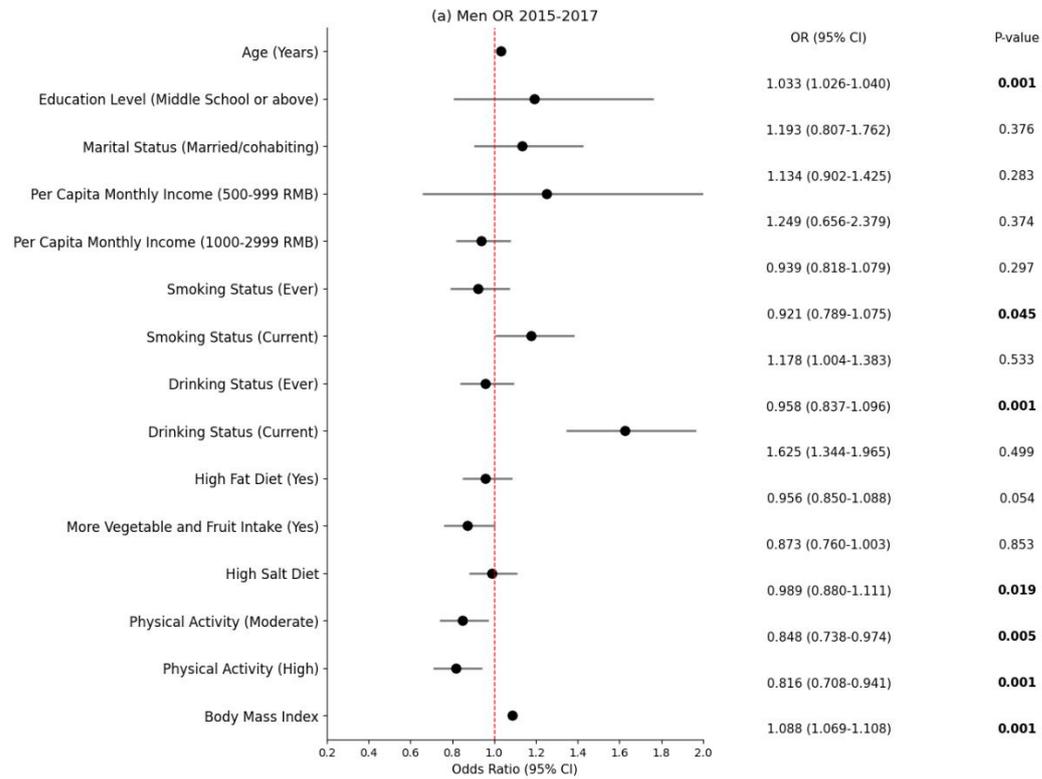
Note 4. Check BP in both arms to determine whether HTN is the cause⁷:

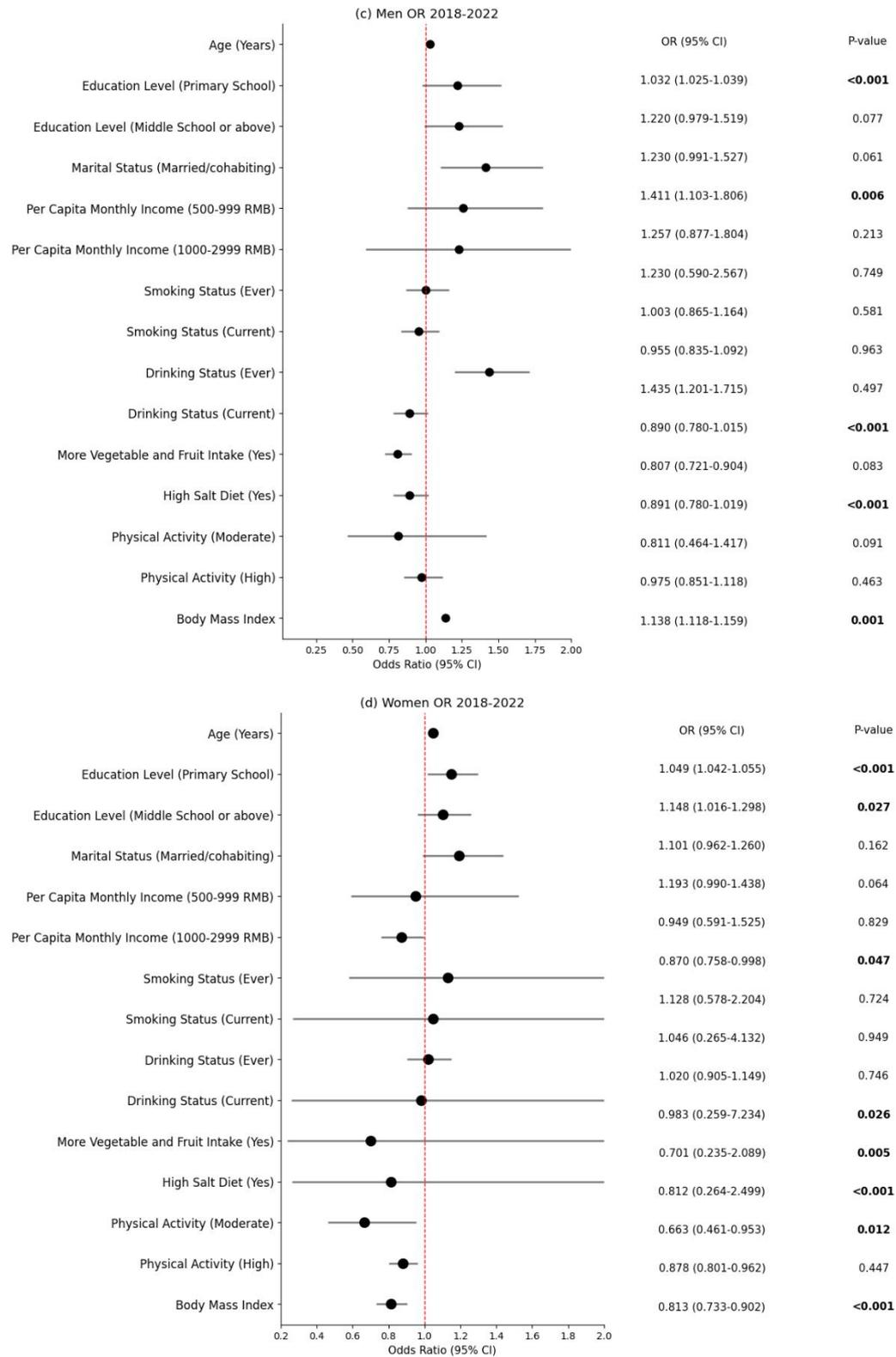
- Measurements were taken if there was a discrepancy of more than 15 mmHg between the two arms.
- Perform another reading of BP. If there is a substantial difference between the two readings, the arm with the higher reading is considered greater than 15 mmHg.
- Patients at a high risk of mortality with asymptomatic peripheral vascular disease, such as subclavian stenosis, could be identified by a difference in SBP of at least 15 mmHg across arms and could benefit from additional testing. ^{7a}

Note 5. If there is convincing evidence of organ damage caused by HBP (such as hypertensive retinopathy with exudates and hemorrhages, left ventricular hypertrophy, or vascular or renal damage), grade 3 HTN can be diagnosed and treated with medication during a single clinic visit. ^{1b}



Supplementary Figure S1. Trends in Hypertension Prevalence, Awareness, Treatment, and Control Rates in Rural Henan, China (2015-2022). Supplementary Figure S1 shows hypertension trends in rural Henan from 2015 to 2022. HTN prevalence increased for men and women. Awareness, treatment, and control rates improved between 2015-2017 and 2018-2022. Graphs A (Men), B (Women), and C (Overall) show HTN prevalence rising over time. Graph D shows standardized rates (2018-2022) for HTN (35.35%), awareness, treatment, and control, adjusted for age 40.





Supplementary Figure S2. Gender Differences in Risk Factor Associations with Hypertension (Rural Henan, China, 2015-2022)

Supplementary Figure S2 reveals variations in risk factors for HTN by gender and survey period.

Age remained a strong risk factor for both genders across all periods.

Men's:

In 2015-2017, lower education and smoking were positively associated with HTN.

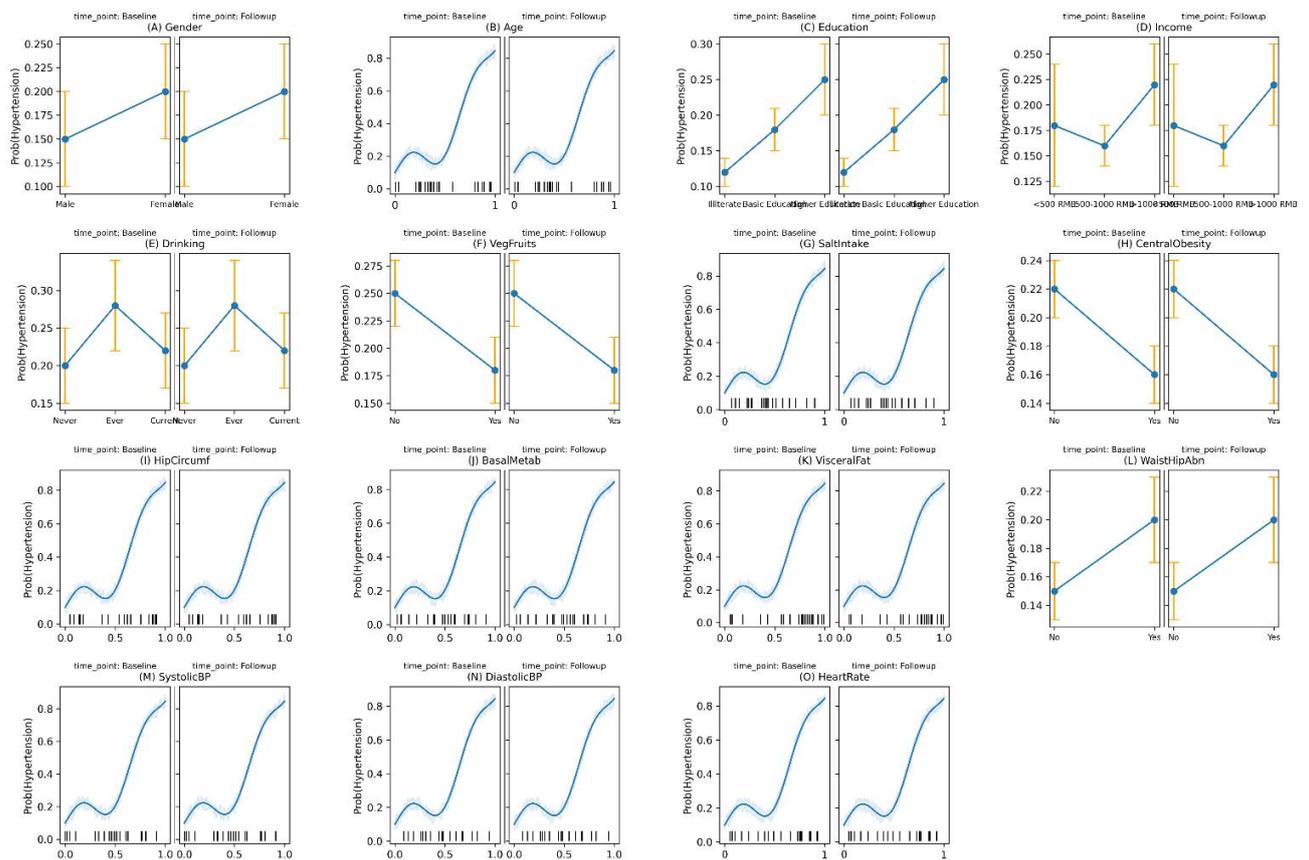
The association between education and HTN in men became less clear in 2018-2022.

Women's: In 2015-2017, higher education showed a possible positive association, although the confidence interval suggests further investigation is needed.

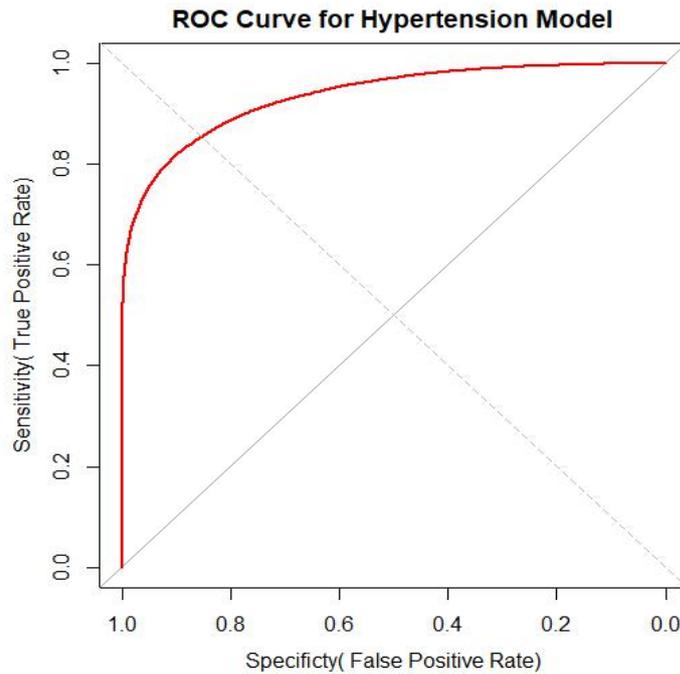
Being married was associated with a lower risk of HTN in 2015-2017.

Between 2018 and 2022, more vegetable intake emerged as a protective factor for Women.

Common risk factors for both genders across all periods included high salt intake, increased BMI, Systolic Blood Pressure (SBP), and Diastolic Blood Pressure (DBP).



Supplementary Figure S3. Change in Hypertension Risk Factors in Rural Henan, China (2015-2022)



Supplementary Figure S4. Performance Evaluation of the GLMM Model for Hypertension Prediction Using ROC Curve Analysis (Rural Henan, China, 2015-2022)

Supplementary Figure S4 of the study depicts a Receiver Operating Characteristic (ROC) curve, which visually assesses the performance of a model designed to predict hypertension. The ROC curve plots sensitivity (correctly identified hypertensive cases) against 1-specificity (false positives) and shows a generally positive trend. This suggests the model has good potential for distinguishing between hypertensive and non-hypertensive individuals within this population.

Rationale and Background for Developing a Novel 7-Category Blood Pressure Classification System

The American College of Cardiology and American Heart Association (ACC/AHA) developed a grading scale for HTN category recommendations. Several established guidelines exist for classifying blood pressure and recommending treatment strategies for hypertension (HTN). The American College of Cardiology and American Heart Association (ACC/AHA) have recently updated their recommendations, suggesting a target blood pressure of 130/80 mmHg for individuals with high cardiovascular (CV) risk^[1]. However, some variations exist across international guidelines, highlighting the need for further research on optimal target blood pressure levels, particularly for Asian populations. Screening and treatment guidelines have changed over the past 20 years, with new recommendations for certain at-risk groups ^[2]. The old guidelines set the target blood pressure for HTN at 140/90 mmHg before the 2017 ACC/AHA guidelines^[3]. The more recent 2018 European Society of Cardiology/European Society of Hypertension's (ESC/ESH), Canadian, and Latin American guidelines, and the American Diabetes Association (ADA) guidelines, propose 140/90 mmHg for adults and

130/80 mmHg for individuals with high CV risk. The 2013 Korean Society of Hypertension (KSH) standards classify prehypertension into two stages based on BP readings. A systolic blood pressure indicates stage 1 (SBP) range of 120-129 mmHg and a Diastolic blood pressure (DBP) range of 80-84 mmHg. Stage 2 is indicated by an SBP range of 130-139 mmHg and a DBP range of 85-89 mmHg^[4]. There are few well-controlled RCTs on target BP among Asians, although there are some cohort data on target BP in certain Asian groups. A recent analysis from the China Stroke Primary Prevention Trial (CSPPT) showed that among adult patients with HBP and no history of stroke, heart attack, diabetes, or kidney problems, aiming for a lower SBP (120-130 mmHg) resulted in the lowest risk of experiencing a first stroke ^[5]. According to several studies, these HBP categories are significantly associated with other disorders. The 2018 Chinese and ESC/ESH of HTN guidelines have maintained the usual threshold and target of 140/90 mmHg for patients^[6,7]. A study of elderly hypertensive patients from northern China found that an SBP range of 130–140 mm Hg had the lowest incidence of cardiovascular disease. However, no specific SBP value has been linked to a reduced risk of negative outcomes^[8]. According to a recent WHO report in 2023, China has a higher prevalence of hypertension in rural areas and among men^[9]. It is a leading risk factor for CVD, and further action is needed to reduce its burden.

Protocol for Early Detection of Hypertension in Patients

Regular BP checks help identify HTN and serve as a valuable baseline test for patients with normotension. Table 1 presents the BP classifications and suggestions for the frequency of BP checking. Please refer to Figure 1 in Module 1 for proper BP measurements. BP classification in the workplace^{Note1} refers to the WHO declaration^{1a} and the ESC/ESH guideline^{1b} and advice for frequent BP monitoring and intervention.

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