

Preplanned Studies

Associations Between Hypertension Status and Increased Heart Rate — China, 2015

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Summary

What is already known on this topic?

Hypertension is a major public health concern in China, and hypertensive patients have elevated heart rates (HR), which can synergize with higher blood pressure to promote adverse health outcomes.

What is added by this report?

The risk of increased HR was statistically significant but relatively lower in subjects with treated and controlled hypertension. This lower impact might be modified by sex, marital status, smoking, and physical activity.

What are the implications for public health practice?

To mitigate the substantial burden of increased HR among hypertensive patients, improving blood pressure control and promoting healthy lifestyles should be prioritized.

With rapid economic development and population aging, China has experienced an epidemic of hypertension. In comparison with general population, hypertensive patients have elevated heart rate (HR). Previous studies have documented the effect of elevated HR on all-cause and cardiovascular mortality (1), and higher HR and blood pressure can work synergistically to promote negative health outcomes (2). As a result, monitoring both blood pressure and HR among hypertensive patients is necessary. Although treatment and control of hypertension are essential for preventing adverse cardiovascular events, their roles in reducing HR are not fully understood. In addition, the extent to which such beneficial effects, if any, are modified by individual-level characteristics remains unexplored. In this study, we recruited a nationally representative sample of the general population from the China Chronic Disease and Risk Factors Surveillance (CCDRFS) in 2015 and collected their data on HR, blood pressure, and antihypertensive treatment. We found that the risk of increased HR was relatively lower in subjects with treated and controlled

hypertension, although it was still significant. Furthermore, the impact on HR varied by subgroups of sex, marital status, smoking status, and physical activity. These results suggest that more efforts aiming to improve blood pressure control and promote healthy lifestyles are required to better regulate HR among hypertensive patients.

CCDRFS was a national survey of Chinese adults aged 18 years old and above and the population in this study were from the wave conducted in 2015. Multistage and cluster-randomized sampling was conducted in 298 counties/districts across 31 provincial-level administrative divisions (PLADs), thus providing a nationally representative sample. A questionnaire covering sociodemographic and lifestyle factors, history of hypertension treatment, and anthropometric measurements were administered to each subject by trained personnel. Among the 189,605 respondents (response rate 95.4%), 7,249 subjects had missing data on blood pressure or HR and 10,194 subjects had incomplete covariates, which resulted in the inclusion of 172,162 subjects in main analyses. Hypertension status was classified as follows: a) not treated (newly diagnosed or not treated with antihypertensive drugs); b) treated and not controlled (treated with antihypertensive drugs and systolic/diastolic blood pressure $\geq 140/90$ mmHg); and c) treated and controlled (treated with antihypertensive drugs and systolic/diastolic blood pressure $< 140/90$ mmHg). Increased HR was defined as more than 80 beats per minute (bpm), which was in accordance with the consensus of the Chinese Specialized Committee on Hypertension (3).

Standard descriptive statistics were presented by calculating mean and standard deviation for continuous variables and frequency and proportion for categorical variables. To account for correlation between subjects from the same cluster, a generalized linear mixed model with random intercepts for each county/district was employed to examine the associations between hypertension status and increased HR [expressed as odds ratio (OR) and 95% confidence

interval (95% CI)]. Model 1 included age, sex, ethnicity, education, marital status, and household income as confounding variables. Model 2 additionally adjusted for smoking, drinking, exercise, salt intake, obesity, and dyslipidemia. In addition, subgroup analyses were also performed to check the modification effects of aforementioned factors. Because biological interactions had more implications in terms of public health, relative excess risk due to interaction (RERI) and attributable proportion (AP) were used to assess interaction at the additive scale (4). RERI and AP>0 meant more than additivity, and otherwise less than additivity. All statistical analyses were performed using R software (version 3.6.0, R Foundation for Statistical Computing), and statistical significance was defined as two-sided $p<0.05$.

Data were available for 172,162 subjects aged ≥ 18 years, whose characteristics were similar with those excluded ($n=17,443$) except that they exhibited higher likelihood of being ethnically Han and physically active. Compared with non-hypertensive subjects, hypertensive patients were more likely to be older, less educated, poorer, obese, lipid dysregulated, and having higher salt intake (Table 1). Of the 68,405 hypertensive patients, 65.0% had untreated hypertension, 26.3% had treated and uncontrolled hypertension, and 8.7% had treated and controlled

hypertension.

As shown in Table 2, the HR of hypertensive subjects was 1 bpm higher than non-hypertensive subjects (76.4 vs. 75.4, $p<0.001$), and the corresponding prevalence of increased HR was 33.3% and 28.4%. Subjects with untreated or treated and uncontrolled hypertension had similar prevalence with overall hypertensive subjects (33.5% and 34.0%, respectively), whereas subjects with treated and controlled hypertension had prevalence closer to non-hypertensive subjects (30.3%). Further stratified analyses by sociodemographic, behavioral, and biological factors showed that the prevalence was significantly higher among people who were younger, female, unmarried, drinker, less physically active, obese, or with dyslipidemia (Supplementary Table S1, available in <http://weekly.chinacdc.cn/>). Results of the mixed effect logistic model supported these differences. After adjusting for covariates, the odds of increased HR was 35% higher for untreated hypertension (OR=1.35, 95% CI: 1.32 to 1.39), 40% higher for treated and uncontrolled hypertension (OR=1.40, 95% CI: 1.34 to 1.45), and 18% higher for treated and controlled hypertension (OR=1.18, 95% CI: 1.11 to 1.25).

Furthermore, the RERI was 0.17 (95% CI: -0.03 to 0.36) for smoking, 0.22 (95% CI: -0.01 to 0.45) for marital status, and 0.19 (95% CI: 0.01 to 0.36) for

TABLE 1. General characteristics of subjects aged 18 years old or above by hypertension status in China, 2015.

Variable	Non-hypertensive subjects (n=103,757)	Hypertensive subjects			
		Total (n=68,405)	Not treated (n=44,435)	Treated and not controlled (n=18,019)	Treated and controlled (n=5,951)
Age (mean \pm SD)	47.6 \pm 14.0	59.3 \pm 12.0	57.6 \pm 12.5	62.8 \pm 10.2	62.2 \pm 10.1
Men (n, %)	46,672 (45.0)	33,474 (48.9)	23,016 (51.8)	7,787 (43.2)	2,671 (44.9)
Ethnically Han (n, %)	90,567 (87.3)	61,747 (90.3)	39,483 (88.9)	16,662 (92.5)	5,602 (94.1)
Senior high school or above (n, %)	24,491 (23.6)	10,451 (15.3)	6,438 (14.5)	2,599 (14.4)	1,414 (23.8)
Married (n, %)	94,568 (91.1)	62,125 (90.8)	40,567 (91.3)	16,179 (89.8)	5,379 (90.4)
Household income (n, %)					
<10,000 CNY	9,024 (8.7)	8,596 (12.6)	5,563 (12.5)	2,472 (13.7)	561 (9.4)
10,000–49,999 CNY	48,186 (46.4)	31,592 (46.2)	21,052 (47.4)	8,136 (45.2)	2,404 (40.4)
$\geq 50,000$ CNY	30,074 (29.0)	17,028 (24.9)	10,026 (22.6)	4,795 (26.6)	2,207 (37.1)
Don't know/refuse to answer	16,473 (15.9)	11,189 (16.3)	7,794 (17.5)	2,616 (14.5)	779 (13.1)
Current smoking (n, %)	27,247 (26.3)	17,786 (26.0)	12,762 (28.7)	3,755 (20.8)	1,269 (21.3)
Current drinking (n, %)	38,430 (37.0)	24,639 (36.0)	17,467 (39.3)	5,316 (29.5)	1,856 (31.2)
Physical inactivity (n, %)	18,249 (17.6)	12,985 (19.0)	8,491 (19.1)	3,373 (18.7)	1,121 (18.8)
High salt intake (n, %)	62,621 (60.4)	43,909 (64.2)	28,699 (64.6)	11,744 (65.2)	3,466 (58.2)
Obesity (n, %)	10,117 (9.8)	14,409 (21.1)	8,293 (18.7)	4,803 (26.7)	1,313 (22.1)
Dyslipidemia (n, %)	35,565 (34.3)	32,139 (47.0)	18,910 (42.6)	9,926 (55.1)	3,303 (55.5)

TABLE 2. Blood pressure, heart rate, and risk of increased heart rate of subjects aged 18 years old or above by hypertension status in China, 2015.

	SBP (mmHg, mean±SD)	DBP (mmHg, mean±SD)	HR (bpm, mean±SD)	HR >80 bpm (n, %)	OR (95% CI)	
					Model 1 [*]	Model 2 [†]
Non-hypertensive subjects	121.1±10.7	73.8±8.1	75.4±10.4	29,440 (28.4)	ref	ref
Total hypertensive subjects	153.6±17.9	86.8±11.5	76.4±11.8	22,800 (33.3)	1.39 (1.36 to 1.42)	1.35 (1.32 to 1.38)
Not treated	153.8±15.5	87.4±11.0	76.5±11.8	14,872 (33.5)	1.39 (1.35 to 1.42)	1.35 (1.32 to 1.39)
Treated and not controlled	161.5±18.2	88.7±11.9	76.6±12.1	6,122 (34.0)	1.46 (1.41 to 1.51)	1.40 (1.34 to 1.45)
Treated and controlled	128.5±8.5	76.4±7.9	75.9±11.0	1,806 (30.3)	1.23 (1.16 to 1.31)	1.18 (1.11 to 1.25)

Abbreviation: SBP=systolic blood pressure; DBP=diastolic blood pressure; HR=heart rate; OR=odds ratio; CI=confidence interval; REF=reference.

^{*}Adjusted for age, sex, ethnicity, education, marital status, and household income.

[†]Adjusted for the same covariates as model 1 plus smoking, drinking, physical activity, salt intake, obesity, and dyslipidemia.

physical activity, suggesting synergistic effects of smoking, unmarried, or physical inactivity and treated and controlled hypertension (Table 3). In contrast, the RERI was -0.33 (95% CI: -0.50 to -0.16) for sex, which indicated that the joint effects of being women and treated and controlled hypertension were less than expected sum of the individual effects.

DISCUSSION

Using a nationally representative sample of China's population, we found that the prevalence of increased HR among hypertensive subjects was 33.3%. Compared with non-hypertensive subjects, the excess risk of increased HR for subjects with untreated or treated uncontrolled hypertension was at least 35%,

while it reduced to 18% for subjects with treated and controlled hypertension. Moreover, the associations between treated and controlled hypertension and increased HR seemed to depend on sex, marital status, smoking status, and physical activity.

A prior cohort study demonstrated that hypertensive individuals with HR ≥ 80 bpm had 51% and 38% higher risk for mortality from cardiovascular diseases and all causes than those with HR < 60 bpm (5). Hence, increasing concerns have been raised regarding dysregulated HR among hypertensive patients. However, few Chinese studies have directly assessed its prevalence at the national level. In 2014, Sun et al. assembled data of outpatients from 136 hospitals located in 21 cities and reported that 38.2% of uncomplicated hypertensive patients had HR ≥ 80 bpm

TABLE 3. Additive interaction of treated and controlled hypertension and several characteristics on increased heart rate in China, 2015.

Item	OR (95% CI) [*]	Additive interaction	
		RERI (95% CI)	AP (95% CI)
Sex			
Men	1.42 (1.30 to 1.55)	-0.33 (-0.50 to -0.16)	-0.22 (-0.34 to -0.10)
Women	1.04 (0.97 to 1.13)		
Marital status			
Married	1.18 (1.11 to 1.26)	0.22 (-0.01 to 0.45)	0.13 (0.00 to 0.26)
Not married	1.28 (1.07 to 1.53)		
Smoking status			
Non-smoker	1.16 (1.09 to 1.24)	0.17 (-0.03 to 0.36)	0.11 (-0.01 to 0.23)
Smoker	1.31 (1.15 to 1.48)		
Physical inactivity			
No	1.18 (1.10 to 1.26)	0.19 (0.01 to 0.36)	0.12 (0.01 to 0.23)
Yes	1.27 (1.11 to 1.44)		

Abbreviation: RERI=relative excess risk due to interaction; AP=attributable proportion; CI=confidence interval.

^{*}Adjusted for age, ethnicity, education, household income, drinking, salt intake, obesity, dyslipidemia, and for sex, marital status, smoking, physical activity when appropriate. Reference category: non-hypertensive subjects.

(6). Our analysis extended this result by analyzing the general population, and the corresponding prevalence was 35.1% using the same cutoff value as their study. Despite the modest decrease in prevalence, caution is needed when concluding the trend of increased HR over time because of possibly more severe hypertension in hospital-based patients. Our estimated prevalence 33.3% coupled with the Chinese population size (1.37 billion) and hypertension prevalence (29.0%) translated to a total of 132 million hypertensive patients having increased HR in 2015. This number should urge policymakers to strengthen the regulation of HR in people with hypertension.

We found that the risk of increased HR was relatively lower in people with treated and controlled hypertension than those with untreated or treated uncontrolled hypertension. The biological mechanisms underpinning these differences are unclear. One explanation is that controlled hypertension is merely an indicator of reduced sympathetic activity that negatively controls HR (7). Another explanation is that high blood pressure causes damage to cardiovascular system and HR increases to compensate for this damage, so decreasing blood pressure would decrease this compensatory adaptation. However, the sustained higher risk suggested that current criteria designating blood pressure control might not be sufficient to reverse the increased HR to levels observed in non-hypertensive subjects. It is also possible that the antihypertensive drug used, such as β -blocker, can exert impacts on both blood pressure and HR. Thus, it would be valuable to compare HR by classes of antihypertensive drugs. Since this information was not collected in CCDRFS, future studies are warranted to explore this topic.

Interestingly, the impact of treated and controlled hypertension on HR appeared to be modified by several risk factors. First, the estimate seemed to be larger in smokers, which is supported by the direct link between smoking and stimulated sympathetic nervous system (8). Second, the stronger association in people exercising less was not surprising as inactive people generally have higher HR than active people (9). Third, men were found to have much higher risk than women. This could be explained by the greater likelihood of men being smokers, drinkers, or having inactive lifestyles. Finally, the fast pace of life commonly seen in unmarried people might result in more psychological stress, which in turn might lead to increased HR.

This study was subject to some limitations. Due to lack of data on medication history as mentioned above,

the impact of finer categories of hypertension treatment on HR could not be elucidated. In addition, some important covariates including intake of tea and/or coffee were not available, leaving the possibility of residual confounding.

In summary, the risk of increased HR differed by hypertension status, with lower risk in people with treated and controlled hypertension. The lower risk was more pronounced among women, nonsmokers, and those married or exercising regularly. To mitigate the substantial burden of increased HR among hypertensive patients, improving blood pressure control and promoting healthy lifestyles should be prioritized.

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SUPPLEMENTARY TABLE S1. The prevalence of increased heart rate stratified by both characteristics and hypertension status in China, 2015.

Variable	Non-hypertensive subjects (n=103,757)			Hypertensive subjects (n=68,405)								
				Not treated (n=44,435)			Treated and not controlled (n=18,019)			Treated and controlled (n=5,951)		
	n	%	p-value [†]	n	%	p-value [†]	n	%	p-value [†]	n	%	p-value [†]
Age												
≤52.4 years [*]	66,077	29.3	<0.001	15,351	37.2	<0.001	3,007	36.2	0.003	1,010	31.2	0.441
>52.4 years [*]	37,680	26.7		29,084	31.5		15,012	33.5		4,941	30.2	
Sex												
Men	46,672	25.0	<0.001	23,016	32.0	<0.001	7,787	32.3	<0.001	2,671	29.8	0.324
Women	57,085	31.1		21,419	35.1		10,232	35.2		3,280	30.8	
Ethnicity												
Non-Han	13,190	30.1	0.141	4,952	34.7	0.064	1,357	36.3	0.037	349	33.5	0.133
Han	90,567	28.1		39,483	33.3		16,662	33.8		5,602	30.1	
Educational level												
Low	79,266	28.6	0.002	37,997	33.3	0.096	15,420	34.4	0.008	4,537	31.6	0.001
High	24,491	27.8		6,438	34.3		2,599	31.5		1,414	26.3	
Marital status												
Unmarried	9,189	34.2	<0.001	3,868	38.2	<0.001	1,840	38.6	<0.001	572	37.9	<0.001
Married	94,568	27.8		40,567	33.0		16,179	33.5		5,379	29.5	
Household income												
<10,000 CNY	9,024	30.2	ref	5,563	32.6	ref	2,472	34.0	ref	561	36.2	ref
10,000–49,999 CNY	48,186	28.5	0.86	21,052	32.9	0.335	8,136	34.3	0.914	2,404	32.1	0.094
≥50,000 CNY	30,074	27.0	0.109	10,026	34.2	0.032	4,795	32.8	0.222	2,207	27.2	<0.001
Don't know/refuse to answer	16,473	29.4	0.188	7,794	34.6	0.068	2,616	35.1	0.85	779	29.7	0.025
Current Smoking												
No	76,510	29.0	<0.001	31,673	33.5	0.522	14,264	34.2	0.18	4,682	30.2	0.871
Yes	27,247	26.5		12,762	33.4		3,755	33.0		1,269	30.8	
Alcohol use												
No	65,327	30.1	<0.001	26,968	34.5	<0.001	12,703	35.0	<0.001	4,095	31.3	0.042
Yes	38,430	25.5		17,467	31.9		5,316	31.5		1,856	28.2	
Physical activity												
Inactive	182,499	32.0	<0.001	8,491	37.3	<0.001	3,373	39.4	<0.001	1,121	35.2	<0.001
Active	85,508	27.6		35,944	32.6		14,646	32.7		4,830	29.2	
Salt intake												
Low	411,366	28.0	0.392	15,736	33.9	0.307	6,275	34.4	0.561	2,485	30.0	0.98
High	62,621	28.6		28,699	33.3		11,744	33.8		3,466	30.6	
Obesity												
No	936,400	28.2	<0.001	36,142	32.8	<0.001	13,216	34.0	0.527	4,638	29.9	0.084
Yes	10,117	30.1		8,293	36.3		4,803	34.0		1,313	32.1	
Dyslipidemia												
No	68,192	27.7	<0.001	25,525	31.0	<0.001	8,093	32.2	<0.001	2,648	29.4	0.07
Yes	35,565	29.7		18,910	36.8		9,926	35.4		3,303	31.1	

^{*}The median of age among total population.

[†]p values were derived from univariate generalized linear mixed model.