


ORIGINAL PAPER

Social determinants status and hypertension: A Nationwide Cross-sectional Study in China

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Abstract

To explore the association between unbalanced social determinants status and hypertension (HTN) in China, we conducted a cross-sectional survey in a sample of 299 220 Chinese in 2012 to 2015. Social determinants status were measured with: (a) district-level: Per capita GDP (Per_GDP), the number of hospital beds per 1000 residents (Per_1000_bed) and tertiary industry added value (TIAV); (b) individual-level: education and employment conditions. Compared with the poorest level of Per_GDP, the middle and richest group had higher risk of HTN [OR, 95%CI: 1.12 (1.09-1.14) and 0.99 (0.96-1.02)] and higher possibility of HTN awareness, treatment, and control. Higher risk of HTN and lower possibility of awareness, treatment, and control were associated with elevated Per_1000_bed in rural area. Higher possibility of HTN control was associated with the higher TIAV ($P_{\text{trend}} < .001$). Those with middle (OR, 95%CI: 0.86, 0.84-0.88) and senior (OR, 95%CI: 0.72, 0.69-0.76) education had a decreased risk of HTN and higher HTN control possibility compared to primary. And participants in retirement/unemployment conditions had a higher risk of HTN and higher possibility of HTN awareness, treatment, and control compared with the job-holders. This study provides evidence from China that social determinants status has a detectable association with HTN. People with a higher economic area living, lower level of education, or retirement/unemployment conditions has a higher risk of HTN, especially for male or rural residents. And lower possibility of HTN awareness, treatment, and control were associated with worse economic development and social circumstances environment, lower education level, and employment/student conditions.

1 | INTRODUCTION

Hypertension (HTN) is the leading modifiable risk factor for cardiovascular disease (CVD), and high systolic blood pressure is the top risk factor for both number of deaths and percentage of disability-adjusted life-years (DALYs), of which 95.7% were due to CVD.¹

The prevalence of HTN and pre-HTN continues to increase in China recently, and posed a substantial public health challenge.²

Men, aging, overweight/obesity, family history of HTN, smoking, and alcohol drinking were all significantly associated with an increased risk of HTN.^{2,3} Social determinants of health are the result of a combination of social policies and economic arrangements,

TABLE 1 Characteristics of study participants by sex and area

Characteristics	Total	Sex		P value for sex	Area		P value for area
		Male	Female		Urban	Rural	
n (%)	299 220 (100)	143 524 (47.97)	155 696 (52.03)	--	124 761 (41.7)	174 459 (58.3)	--
Age, y	48.2 (48.2-48.3)	48.0 (47.9-48.1)	48.4 (48.3-48.5)	<.001	47.7 (47.6-47.8)	48.6 (48.5-48.7)	<.001
SBP, mm Hg	127.81 (127.74-127.88)	129.21 (129.12-129.3)	126.51 (126.41-126.61)	<.001	126.88 (126.77-126.98)	128.47 (128.38-128.56)	<.001
DBP, mm Hg	75.53 (75.49-75.56)	77.2 (77.14-77.25)	73.99 (73.93-74.04)	<.001	75.17 (75.12-75.23)	75.78 (75.73-75.83)	<.001
HTN-related crude rate (%)							
Prevalence	28.23 (28.07-28.39)	28.69 (28.45-28.92)	27.81 (27.58-28.03)	<.001	27.32 (27.07-27.57)	28.88 (28.67-29.09)	<.001
Awareness	51.39 (51.06-51.73)	47.36 (46.88-47.84)	55.23 (54.76-55.7)	<.001	53.05 (52.52-53.58)	50.28 (49.84-50.71)	<.001
Treatment	45.63 (45.3-45.97)	41.08 (40.61-41.56)	49.96 (49.49-50.43)	<.001	47.93 (47.4-48.46)	44.08 (43.65-44.52)	<.001
Control	16.23 (15.98-16.48)	14.71 (14.37-15.06)	17.67 (17.31-18.03)	<.001	18.54 (18.13-18.95)	14.66 (14.36-14.97)	<.001
Ethnicity (Han, %)	88.6 (88.48-88.71)	88.73 (88.56-88.89)	88.48 (88.32-88.64)	<.001	87.61 (87.43-87.79)	89.3 (89.16-89.45)	<.001
Smoking, %							
Current smokers	22.58 (22.43-22.73)	44.45 (44.2-44.71)	2.42 (2.35-2.5)	<.001	21.55 (21.32-21.78)	23.32 (23.12-23.52)	<.001
Past smokers	3.31 (3.24-3.37)	6.42 (6.29-6.55)	0.43 (0.4-0.47)		3.09 (2.99-3.19)	3.46 (3.38-3.55)	
Non-smokers	74.11 (73.95-74.27)	49.13 (48.87-49.39)	97.14 (97.06-97.22)		75.36 (75.12-75.6)	73.22 (73.01-73.43)	
Alcohol drinking, %	22.62 (22.47-22.77)	40.55 (40.3-40.8)	6.09 (5.97-6.21)	<.001	21.62 (21.39-21.85)	23.33 (23.13-23.53)	<.001
Family history of hypertension, %	22.85 (22.7-23)	21.89 (21.68-22.11)	23.73 (23.52-23.94)	<.001	23.59 (23.36-23.83)	22.31 (22.12-22.51)	<.001
Family history of CVD, %	7 (6.91-7.1)	6.49 (6.36-6.62)	7.48 (7.35-7.61)	<.001	7.01 (6.87-7.15)	7 (6.88-7.12)	<.001
BMI, Kg/m ²	23.81 (23.79-23.82)	23.85 (23.84-23.87)	23.76 (23.75-23.78)	<.001	23.84 (23.82-23.86)	23.79 (23.77-23.8)	<.001
Anti-hypertensive drug, %	12.88 (12.76-13)	11.79 (11.62-11.95)	13.89 (13.72-14.06)	<.001	13.09 (12.91-13.28)	12.73 (12.57-12.89)	.0034
Education, %							
Primary	41.94 (41.76-42.11)	34.7 (34.45-34.94)	48.61 (48.36-48.86)	<.001	33.2 (32.94-33.46)	48.19 (47.95-48.42)	<.001
Middle	47.49 (47.31-47.67)	54.02 (53.76-54.27)	41.48 (41.23-41.72)		51.07 (50.8-51.35)	44.93 (44.7-45.16)	
Senior	10.57 (10.46-10.68)	11.29 (11.12-11.45)	9.91 (9.77-10.06)		15.73 (15.53-15.93)	6.88 (6.77-7)	
Employment conditions, %							
Employment	59.54 (59.37-59.72)	63.49 (63.24-63.74)	55.91 (55.66-56.16)	<.001	56 (55.72-56.27)	62.08 (61.85-62.31)	<.001
Retirement	6.39 (6.31-6.48)	6.69 (6.56-6.82)	6.12 (6-6.24)		11.71 (11.53-11.89)	2.59 (2.52-2.67)	
Students	4.34 (4.27-4.41)	4.33 (4.23-4.44)	4.35 (4.25-4.45)		5.4 (5.27-5.52)	3.59 (3.5-3.67)	
Unemployment	29.72 (29.56-29.89)	25.49 (25.26-25.71)	33.63 (33.39-33.86)		26.9 (26.65-27.14)	31.74 (31.52-31.96)	

Note: Data are means and their 95% CIs, and the categorical variables are presented as percentages and their 95% CIs. P < .05: The group difference assessed by 2 test was significant. Abbreviations: CVD, cardiovascular disease; DBP, diastolic blood pressure; SBP, systolic blood pressure. Family history of CVD, family history of coronary heart disease and/or stroke.

TABLE 2 Adjusted OR (95%CI) stratified by sex

	HTN			Awareness of HTN		
	Overall	Male	Female	Overall	Male	Female
Per_GDP						
Poorest third	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Middle third	1.12 (1.09-1.14)	1.15 (1.11-1.19)	1.09 (1.05-1.12)	0.95 (0.92-0.98)	0.95 (0.90-1.00)	0.96 (0.91-1.00)
Richest third	0.99 (0.96-1.02)	1.01 (0.97-1.05)	0.96 (0.93-1.00)	1.16 (1.11-1.21)	1.21 (1.14-1.29)	1.13 (1.07-1.20)
<i>P</i> for trend	.006	.001	.321	<.001	<.001	<.001
<i>P</i> _{interaction}	--	<.001	--	.234	---	.412
Per 1000_bed						
Least third	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Middle third	1.09 (1.07-1.12)	1.09 (1.06-1.13)	1.09 (1.06-1.13)	0.91 (0.88-0.94)	0.89 (0.84-0.94)	0.93 (0.89-0.98)
Most third	1.06 (1.03-1.10)	1.04 (0.99-1.08)	1.10 (1.05-1.14)	0.90 (0.87-0.94)	0.88 (0.83-0.93)	0.93 (0.88-0.98)
<i>P</i> for trend	<.001	.012	<.001	.001	<.001	.176
<i>P</i> _{interaction}	--	.004	--	.781	---	.659
TIAV						
Poorest third	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Middle third	0.93 (0.91-0.95)	0.94 (0.91-0.97)	0.91 (0.88-0.95)	0.91 (0.88-0.95)	0.93 (0.88-0.98)	0.89 (0.85-0.94)
Richest third	0.99 (0.96-1.01)	0.97 (0.93-1.00)	1.00 (0.96-1.04)	0.95 (0.92-0.99)	0.92 (0.87-0.98)	0.98 (0.92-1.03)
<i>P</i> for trend	.050	.007	.506	.034	.008	.568
<i>P</i> _{interaction}	--	.028	--	.676	---	.549
Education						
Primary	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Middle	0.86 (0.84-0.88)	0.98 (0.95-1.01)	0.75 (0.73-0.78)	1.00 (0.97-1.04)	1.07 (1.02-1.12)	0.94 (0.89-0.99)
Senior	0.72 (0.69-0.76)	1.01 (0.96-1.07)	0.39 (0.36-0.43)	0.79 (0.72-0.86)	0.95 (0.86-1.05)	0.52 (0.44-0.62)
<i>P</i> for trend	<.001	.367	<.001	.494	.011	<.001
<i>P</i> _{interaction}	--	<.001	--	.348	---	.738
Employment conditions						
Employment	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Retirement	1.33 (1.29-1.38)	1.39 (1.33-1.47)	1.35 (1.28-1.42)	1.47 (1.40-1.55)	1.45 (1.35-1.55)	1.47 (1.37-1.59)
Students	0.72 (0.65-0.80)	0.70 (0.62-0.80)	0.76 (0.63-0.91)	0.30 (0.21-0.45)	0.36 (0.22-0.57)	0.26 (0.14-0.49)
Unemployment	1.07 (1.05-1.10)	1.05 (1.02-1.09)	1.09 (1.06-1.13)	1.21 (1.17-1.25)	1.18 (1.13-1.24)	1.24 (1.19-1.30)
<i>P</i> for trend	--	--	--	--	--	--
<i>P</i> _{interaction}	--	<.001	--	.9134	--	.870

Abbreviations: HTN, hypertension; Per_GDP, Per capita GDP; Per 1000_bed, the number of hospital beds per 1000 residents; TIAV, tertiary industry added value. The model was adjusted for age, sex (excluded in sex stratified analysis), areas, ethnicity, smoking, alcohol drinking and family history of hypertension.

in which people are born, grow, live, work and age, and the systems put in place to deal with illness; social determinants status reflect the following points: their access to health care, schools, and education, their conditions of work and leisure, their homes, communities, towns, or cities.⁴ Although several reviews have assessed the effects of social determinants status on the HTN or CVD epidemic in communities and countries,⁵ there is a paucity of information about the association between HTN and social determinants throughout China.

In the current study, using data from the China Hypertension Survey (CHS), we explored the association between regional unbalanced social determinants status and HTN in China. We hypothesized that Per capita GDP (Per_GDP), the number of hospital beds

per 1000 residents (Per1000_bed), tertiary industry added value (TIAV), education and employment conditions have a detectable association with HTN prevalence, awareness, treatment, and control.

2 | METHODS

2.1 | Study design and population

The CHS study protocol has been described in detail previously.⁶ Briefly, a stratified multistage random sampling method was used to obtain a nationally representative sample of the general Chinese

Treatment of HTN			Control of HTN		
Overall	Male	Female	Overall	Male	Female
1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
1.00 (0.97-1.04)	1.00 (0.95-1.05)	1.01 (0.96-1.06)	1.11 (1.06-1.17)	1.12 (1.04-1.21)	1.10 (1.04-1.18)
1.16 (1.11-1.21)	1.19 (1.11-1.26)	1.14(1.07-1.21)	1.36 (1.29-1.44)	1.43 (1.31-1.56)	1.31 (1.22-1.42)
<.001	<.001	<.001	<.001	<.001	<.001
--	.184				
1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
0.89 (0.86-0.92)	0.86 (0.81-0.90)	0.92 (0.87-0.96)	0.80 (0.77-0.84)	0.82 (0.76-0.88)	0.79 (0.74-0.84)
0.93 (0.89-0.97)	0.88 (0.82-0.94)	0.97 (0.91-1.03)	0.88 (0.83-0.93)	0.92 (0.84-1.00)	0.85 (0.78-0.92)
.0280	.002	.800	<.001	.062	<.001
--	.593				
1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
0.87 (0.84-0.91)	0.88 (0.83-0.93)	0.87 (0.82-0.91)	0.92 (0.88-0.97)	0.95 (0.88-1.02)	0.90 (0.84-0.96)
1.01 (0.97-1.05)	0.97 (0.92-1.03)	1.04 (0.98-1.10)	1.10 (1.04-1.16)	1.08 (1.00-1.17)	1.11 (1.04-1.20)
.527	.388	.130	<.001	.027	<.001
--	.869				
1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
1.01 (0.97-1.05)	1.06 (1.01-1.12)	0.96 (0.91-1.01)	1.13 (1.08-1.18)	1.09 (1.02-1.16)	1.18 (1.10-1.26)
0.79 (0.73-0.86)	0.94 (0.85-1.04)	0.56 (0.48-0.67)	0.95 (0.85-1.06)	1.06 (0.93-1.21)	0.76 (0.62-0.95)
.691	.008	.048	<.001	<.001	<.001
--	<.001				
1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
1.54 (1.47-1.62)	1.48 (1.38-1.59)	1.57 (1.46-1.69)	1.40 (1.32-1.49)	1.31 (1.20-1.43)	1.42 (1.30-1.55)
0.31 (0.20-0.47)	0.33 (0.19-0.57)	0.33 (0.17-0.62)	0.28 (0.15-0.50)	0.30 (0.13-0.69)	0.28 (0.11-0.69)
1.21 (1.17-1.25)	1.17 (1.12-1.23)	1.24 (1.19-1.30)	1.09 (1.05-1.14)	1.02 (0.96-1.10)	1.13 (1.07-1.20)
--	--	--	--	--	--
--	.507				

population from all 31 provinces and 262 districts across China from 2012 to 2015. Nearly, a half-million participants aged ≥ 15 years were expected to be surveyed. 733 600 subjects were randomly selected after considered the non-response, and finally 487 349 were recruited (response rate 66.4%). Of the original 487 349 participants in CHS, 188 129 participants were excluded because of lacking the social determinant indicators data or under 18 years old, 299 220 adults from 181 districts of 31 provinces were for the current analysis.

All participants provided informed written consent. The protocol and operational procedures of the CHS study were approved by the Fuwai Hospital (Beijing, China) Ethics Committee.

2.2 | Data collection and definition

A standardized questionnaire was developed by the coordinating center, Fuwai Hospital (Beijing, China). Data on demographic and other factors, including education, employment conditions, family history of HTN, lifestyle (such as smoking and alcohol consumption), and medication use were recorded by interview. Blood pressure (BP) was measured with the OMRON HBP-1300 Professional Portable Blood Pressure Monitor (OMRON) three times on the right arm supported at heart level after the participant was sitting at rest for 5 minutes, with 30 seconds between each measurement.

TABLE 3 Adjusted OR (95%CI) stratified by area

	HTN			Awareness of HTN		
	Overall	Urban	Rural	Overall	Urban	Rural
Per_GDP						
Poorest third	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Middle third	1.12 (1.09-1.14)	1.16 (1.11-1.21)	1.11 (1.08-1.14)	0.95 (0.92-0.98)	1.01 (0.94-1.08)	0.93 (0.89-0.97)
Richest third	0.99 (0.96-1.02)	0.95 (0.91-0.99)	1.03 (1.00-1.07)	1.16 (1.11-1.21)	1.48 (1.38-1.58)	0.96 (0.91-1.02)
<i>P</i> for trend	.006	.016	<.001		<.001	.366
<i>P</i> _{interaction}	--	.005	--	<.001	---	<.001
Per 1000_bed						
Least third	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Middle third	1.09 (1.07-1.12)	0.93 (0.88-0.98)	1.15 (1.12-1.18)	0.91 (0.88-0.94)	1.03 (0.95-1.12)	0.88 (0.84-0.91)
Most third	1.06 (1.03-1.10)	0.97 (0.93-1.02)	1.02 (0.97-1.06)	0.90 (0.87-0.94)	0.95 (0.89-1.02)	0.94 (0.87-1.01)
<i>P</i> for trend	<.001	.510	<.001		.434	<.001
<i>P</i> _{interaction}	--	.005	--	<.001	---	<.001
TIAV						
Poorest third	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Middle third	0.93 (0.91-0.95)	0.95 (0.90-0.99)	0.95 (0.93-0.98)	0.91 (0.88-0.95)	0.90 (0.83-0.97)	0.87 (0.84-0.91)
Richest third	0.99 (0.96-1.01)	1.11 (1.05-1.16)	0.93 (0.90-0.96)	0.95 (0.92-0.99)	0.78 (0.72-0.84)	1.05 (1.00-1.11)
<i>P</i> for trend	.050	<.001	<.001		<.001	.878
<i>P</i> _{interaction}	--	.019	--	.089	---	.017
Education						
Primary	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Middle	0.86 (0.84-0.88)	0.89 (0.86-0.93)	0.83 (0.81-0.86)	1.00 (0.97-1.04)	1.06 (1.01-1.12)	0.96 (0.92-1.01)
Senior	0.72 (0.69-0.76)	0.80 (0.75-0.85)	0.64 (0.60-0.69)	0.79 (0.72-0.86)	0.77 (0.69-0.86)	0.85 (0.74-0.97)
<i>P</i> for trend	<.001	<.001	<.001		.962	.055
<i>P</i> _{interaction}	--	<.001	--	.808	---	.095
Employment conditions						
Employment	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Retirement	1.33 (1.29-1.38)	1.42 (1.36-1.49)	1.30 (1.22-1.39)	1.47 (1.40-1.55)	1.34 (1.26-1.44)	1.45 (1.33-1.58)
Students	0.72 (0.65-0.80)	0.75 (0.65-0.87)	0.70 (0.60-0.81)	0.30 (0.21-0.45)	0.32 (0.19-0.54)	0.30 (0.17-0.53)
Unemployment	1.07 (1.05-1.10)	1.22 (1.17-1.26)	1.01 (0.98-1.04)	1.21 (1.17-1.25)	1.13 (1.07-1.20)	1.25 (1.20-1.30)
<i>P</i> for trend	--	--	--		--	--
<i>P</i> _{interaction}	--	<.001	--	.009		<.001

Abbreviations: HTN, hypertension; Per_GDP, Per capita GDP; Per 1000_bed, the number of hospital beds per 1000 residents; TIAV, tertiary industry added value. The model was adjusted for age, sex, urban/rural areas (excluded in area stratified analysis), ethnicity, smoking, alcohol drinking, and family history of hypertension.

The average of the three readings was used for analysis.⁷ According to 2010 Chinese guidelines for the management of HTN, HTN was defined as systolic BP (SBP) ≥ 140 mm Hg and/or diastolic BP (DBP) ≥ 90 mm Hg and/or use of antihypertensive medication within 2 weeks.⁸ Awareness of HTN was defined as self-report of any previous diagnosis of HTN by a doctor, treatment as self-reported use of a prescription medication for HTN within 2 weeks at the time of the interview, control as SBP < 140 mm Hg and DBP < 90 mm Hg.

Social determinants status was measured with the following indicators: (a) the district-level economic was estimated by Per_GDP, healthcare availability was estimated by Per 1000_bed, and social circumstances were estimated by TIAV. All the 181 districts' three indicators of the survey year were supported by the National Bureau

of Statistics of China. (b) individual-level factors: Education was categorized as no or primary school education only (primary), middle school (middle), or completion of college, university, or postgraduate (senior). Employment conditions were divided into four classes: employment (job-holders), retirement, students, and unemployment.

2.3 | Statistical analysis

The characteristics of study participants were presented as mean (95%CI) for continuous variables and as percentages (95%CI) for the categorical variables, and two-tailed Student's *t* tests and chi-square tests were used to compare the variables, respectively. The linear trend

Treatment of HTN			Control of HTN		
Overall	Urban	Rural	Overall	Urban	Rural
1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
1.00 (0.97-1.04)	1.20 (1.12-1.29)	0.94 (0.90-0.98)	1.11 (1.06-1.17)	1.31 (1.19-1.44)	1.06 (1.00-1.12)
1.16 (1.11-1.21)	1.60 (1.49-1.72)	0.92 (0.87-0.98)	1.36 (1.29-1.44)	2.12 (1.92-2.33)	1.01 (0.93-1.09)
<.001	<.001	.134	<.001	<.001	.165
---	<.001				
1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
0.89 (0.86-0.92)	0.97 (0.89-1.06)	0.87 (0.83-0.90)	0.80 (0.77-0.84)	1.01 (0.91-1.13)	0.76 (0.72-0.81)
0.93 (0.89-0.97)	0.99 (0.92-1.06)	0.98 (0.91-1.06)	0.88 (0.83-0.93)	0.96 (0.88-1.05)	1.01 (0.92-1.11)
.028	.113	<.001	<.001	.282	<.001
---	<.001				
1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
0.87 (0.84-0.91)	0.84 (0.78-0.90)	0.85 (0.81-0.89)	0.92 (0.88-0.97)	0.66 (0.60-0.72)	0.97 (0.91-1.03)
1.01 (0.97-1.05)	0.81 (0.75-0.87)	1.13 (1.08-1.19)	1.10 (1.04-1.16)	0.63 (0.57-0.70)	1.41 (1.32-1.50)
.527	<.001	.019	<.001	<.001	<.001
---	.002				
1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
1.01 (0.97-1.05)	1.08 (1.03-1.15)	0.96 (0.91-1.00)	1.13 (1.08-1.18)	1.22 (1.14-1.31)	1.07 (1.00-1.14)
0.79 (0.73-0.86)	0.77 (0.69-0.86)	0.86 (0.75-0.99)	0.95 (0.85-1.06)	0.95 (0.83-1.09)	1.05 (0.87-1.26)
.691	.183	.058	<.001	<.001	.074
---	.620				
1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
1.54 (1.47-1.62)	1.41 (1.32-1.51)	1.52 (1.40-1.66)	1.40 (1.32-1.49)	1.39 (1.28-1.51)	1.24 (1.11-1.38)
0.31 (0.20-0.47)	0.29 (0.16-0.53)	0.35 (0.19-0.64)	0.28 (0.15-0.50)	0.23 (0.10-0.57)	0.35 (0.16-0.80)
1.21 (1.17-1.25)	1.12 (1.06-1.19)	1.24 (1.20-1.30)	1.09 (1.05-1.14)	1.06 (0.98-1.14)	1.10 (1.05-1.17)
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--	.183				

between HTN-related rate and social determinants indicators at district level was evaluated by linear regression analysis. Multivariate Logistic regression analysis was constructed to examine the association between social determinants status and prevalence, awareness, treatment, and control of HTN. All of the model was adjusted for demographics (eg age, sex, areas, and ethnicity) and HTN risk factors (eg smoking, alcohol drinking, and family history of HTN). Stratified analyses were performed for the basic characteristics of gender (male vs female) and area (urban vs. rural). The three district-level social determinants (Per_GDP, Per 1000_bed, and TIAV) were categorized into 3 groups according to the tertiles of the value in the models. The potential effect modification was detected by examining the interactions of social determinants status and baseline characteristics (sex and area), separately.

All 95% confidence intervals (CI) for the parameters were estimated. A two-sided $P < .05$ was considered significant. Statistical analyses were conducted with SAS version 9.3 (SAS Institute, Inc).

3 | RESULTS

3.1 | Characteristics of the study population

A total of 299 220 individuals from 181 districts and 31 provinces in mainland China were considered for this study, and the characteristics of them were presented in Table 1. The mean age was 48.2 years (47.97% men, 41.70% urban residents), the crude prevalence of HTN

was 28.23%; among individuals with HTN, 51.39% were aware of their condition, 45.63% were taking antihypertensive medications, and 16.23% had controlled HTN. SBP, DBP, current smoking rate, and drinking rate were higher in male and urban participants (P value for sex/region < .001). Female and rural respondents were significantly older, and more likely to have lower education level and higher unemployment rate (P value for sex/area < .001).

3.2 | Hypertension and social determinants status at district level

Overall, HTN prevalence ($r = .16$, $P = .03$), awareness ($r = .29$, $P < .001$), and treatment ($r = .19$, $P = .01$) rates were correlated positively with the Per_GDP of district. Stratified analysis by sex demonstrated that both the prevalence of HTN for male ($r = .18$, $P = .01$) and the HTN treatment rate for female ($r = .20$, $P = .007$) were significantly correlated positively with Per_GDP; the treatment ($r = .15$, $P = .049$) and control ($r = .26$, $P < .001$) rates of HTN were significantly correlated positively with TIAV only for female. However, there was no significant correlation between HTN prevalence, awareness, treatment, and control rate of HTN with Per1000_bed of district.

3.3 | Hypertension and social determinants at individual-level

Compared with the poorest level of Per_GDP, the middle and richest group had higher risk of HTN [OR, 95%CI: 1.12 (1.09-1.14) and 0.99 (0.96-1.02)] and higher possibility of HTN awareness [OR, 95%CI: 1.04 (1.01-1.07) and 1.10 (1.07-1.14)], treatment [OR, 95%CI: 1.00 (0.97-1.04) and 1.16 (1.11-1.21)] and control [OR, 95%CI: 1.11(1.06-1.17) and 1.36 (1.29-1.44)], all P for trend < .05. Higher risk of HTN and lower possibility of HTN awareness, treatment, and control were associated with elevated Per1000_bed (P for trend < .05). Higher possibility of HTN control was associated with the higher level of TIAV (P for trend < .001).

Those with middle (OR, 95%CI: 0.86, 0.84-0.88) and senior (OR, 95%CI: 0.72, 0.69-0.76) education had a decreased risk of HTN and higher possibility of HTN control compared to primary. And compared with the job-holders, those in retirement and unemployment conditions had a higher risk of HTN [OR, 95%CI: 1.33(1.29-1.38) and 1.07(1.05-1.10)] and higher possibility of HTN awareness, treatment, and control; the students had lower risk of HTN (OR, 95%CI: 0.72, 0.65-0.80) but lower possibility of HTN awareness, treatment, and control.

Stratified analysis results by gender and area were presented in Tables 2 and 3, respectively. (a) When stratified by sex, for an increase of Per_GDP or education level, the risk of HTN was slightly larger in male compared with female. Compared with the job-holders, the increase of HTN risk was larger for male retirees (OR, 95%CI: 1.39, 1.33-1.47) than female (OR, 95%CI: 1.35, 1.28-1.42). (b) For subjects who resided in different areas, for an increase of Per_GDP, a significant

increase of HTN risk was only observed among rural subjects [OR (95%CI): 1.11(1.08-1.14) & 1.03(1.00-1.07) for the middle & richest group], however, a significant increase of HTN awareness, treatment, and control was only for urban subjects. Only for rural population, the increased Per 1000_bed was associated with a greater risk of HTN [OR (95%CI): 1.15 (1.12-1.18) & 1.02 (0.97-1.06) for the middle & most group]. And for the TIAV increase, significant decrease of HTN risk as well as increase of treatment and control possibility was observed only among rural population. Elevated education level was significantly associated with lower risk of HTN among rural subjects [OR (95%CI): 0.83 (0.81-0.86) & 0.64 (0.60-0.69) for the middle & senior group] than urban [OR (95%CI): 0.89(0.86-0.93) & 0.80(0.75-0.85) for the middle & senior group]. Compared with the job holders, the increase of HTN risk was greater for urban residents in retirement (OR, 95%CI: 1.42, 1.36-1.49)/unemployment (OR, 95%CI: 1.22, 1.17-1.26) condition than rural [OR (95%CI): 1.30(1.22-1.39) & 1.01(0.98-1.04) for the retirement & unemployment group].

4 | DISCUSSION

This study evaluated the association of social determinants status and HTN on a national scale in China. We found that: (a) participants with a higher economic area living, lower level of education or retirement/unemployment conditions had a higher risk of HTN, especially for male or rural residents; (b) lower possibility of HTN awareness, treatment, and control were associated with worse environment of economic development and social circumstances, lower level of education and employment/student conditions.

Although there were sparse investigations on whether unbalanced Per_GDP or GDP associated with HTN or CVD among different area of a country previously, some were similar with our findings to a certain degree. Herrera-Anazco et al evaluated the association between social determinants of health and trends in the prevalence of HTN among patients of the Peruvian Ministry of Health 2007-2016, they found that the prevalence of HTN rose (from 966.8/100 000 in 2007 to 1619.1/100 000 in 2016) by 3.6/100 000 per 1% increase of Per_GDP.⁹ The published systematic review indicated that there was a positive association between coronary heart disease prevalence and the gross national income per capita ($r = .484$, $P < .01$) in developing countries, while declining in developed countries.¹⁰ Previous studies indicated that diabetes prevalence was positively correlated with national Human Development Index ($r = .421$, $P = .041$) in developing countries at a global level.¹¹ The probable explanation is that economic development brings enormous side effects, such as an unhealthy lifestyle or dietary customs, which are all considered to be HTN risk factors especially in developing nations. It should not be ignored that the national air pollution is worsening from coast to inland, from south to north, from west to east, and from underdeveloped areas to developed areas in China,¹² which was also associated with increased prevalence of HTN.^{13,14} We also observed that higher possibility of HTN control was associated with the higher level of

TIAV. The tertiary industry includes scientific research, education and health, social welfare and so on which probably improve the health awareness, HTN management, and intervention quality.

The inverse association between education and the risk of HTN,^{15,16} and mostly among women and less consistently among men has been well documented.¹⁷⁻¹⁹ A potential explanation may be lower education means a lack of risk perception and an adverse influence on self-seeking behavior or access to healthcare. Similar to our study, Hispanic/Latino females who were homemakers or unemployed had lower rates of ideal cardiovascular health metrics (including blood pressure).²⁰ Tipirneni et al²¹ found that the percent of HTN among employed and out of work were 24.9% and 37.6%, respectively. Evidence from the United States indicated that an increase in a person's working hours reduced the probability of having high blood pressure for male and female workers.²² In the Atherosclerosis Risk in Communities (ARIC) Study, employed women were less likely to develop HTN during the three-year time period than were homemakers (OR = 0.68).²³ For participants who were unable to work might be with the barriers to employment (such as poor health, chronic conditions, older age, or functional limitations) had higher risk of HTN. However, those in retirement or unemployment conditions had a higher possibility of HTN awareness, treatment, and control probable as a result of paying more time and attention on their health. Inconsistent with our results, no association between "Not Working" and HTN was found in a retrospective cohort study of 13 European countries,²⁴ and no clear association of socioeconomic status (employment status, length of education, marital and living status, and household expenditure.) with unaware, untreated, and uncontrolled HTN in a general Japanese population.²⁵ Consistent with previous findings,^{26,27} we observed a lower HTN incidence and lower awareness, treatment and control among adult or college students, thus, the health education should be strengthened to popularize the related knowledge and promote the healthy lifestyle in the students.

In addition, a higher effect estimation of Per_GDP increment and HTN was observed among male in the stratified analysis. A potential explanation is that participants especially male in economically developed areas suffer from higher level of HTN risk factors exposure, such as occupational/relationship stress, unhealthy lifestyle, and air pollution.^{28,29} Besides, it has been examined that there was a potential effect modification of lifestyle, for example, a higher consumption of fruit might mitigate, whereas overweight and obesity could enhance the effect of ambient PM_{2.5} on HTN.¹⁴ And for an increase of Per_GDP or TIAV, a significant increase of HTN risk was only observed among rural not urban residents. The potential mechanism may include with the development of economy or tertiary industry, the levels of HTN risk factors and the prevalence of HTN in rural areas increased more rapidly and has gradually become close to that in urban areas.² Unexpectedly, it has been found that higher risk of HTN, lower possibility of HTN awareness, treatment and control were significantly associated with elevated healthcare availability which was estimated by per 1000_bed in rural rather than urban area. The

probable contributing mechanism of the "paradox": (a) essential resources of HTN and other chronic disease management input was insufficient; (b) the inferior medical staffs and facilities gave rise to the "input-output inefficiency" in rural area.³⁰

4.1 | Strengths and limitations

The main strengths of this study included its national scale and standardized questionnaire and measuring instruments by trained staff. Moreover, the data of the district-level social determinant indicators were authoritative and credible which was provided by the National Bureau of Statistics. And this is the first study to evaluate the association of social determinants status and HTN on a national scale in China. However, several limitations should be noted in this study. Firstly, we did not collect data on the household wealth during the questionnaire investigation which was one of the important socioeconomic status indicators verified by previous studies; Secondly, a certain number of individuals were excluded in the finally analysis because of the lack of district-level social determinant indicators data, this may bring to a bias of the results; Furthermore, in spite of the rigorous study design and standardized measurement, it cannot be denied that BP is an outcome that fluctuates considerably in response to numerous factors, and 45.63% HTN patients were using a single office measure to "diagnose" in the current study, which might result in misclassification of BP and overestimate the prevalence of HTN; Finally, cross-sectional study may preclude a cause relationship between social determinants status and HTN.

5 | CONCLUSIONS

In summary, our study has shown that people with a higher economic area living, lower level of education or retirement/ unemployment conditions have a higher risk of HTN, especially for male or rural residents. And individuals have a lower possibility of HTN awareness, treatment, and control if they are living in a worse economic development and social circumstances environment, undereducated, and in employment/student conditions. The findings add to the growing evidence of the social determinants status effects on HTN. Efforts to reduce unbalanced social determinants conditions should be prioritized accordingly in HTN high-risk population detection and public health initiatives.

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CONFLICT OF INTEREST

None.

AUTHOR CONTRIBUTIONS

Zengwu Wang and Runlin Gao conceived and designed the study. Congyi Zheng, Zengwu Wang, Xin Wang, Zuo Chen, Linfeng Zhang, Yuting Kang, Ying Yang, and Linlin Jiang collected and interpreted the data. Congyi Zheng analyzed the data and drafted the manuscript. Zengwu Wang contributed to critical revision of the manuscript.

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