Original Article

Do Vascular Risk Factors Explain the Socioeconomic Disparities of Hypertension in Chinese?

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Aim: This study aimed to assess the population risk of hypertension attributable to multiple modifiable vascular risk factors to help prevent hypertension, and study the socioeconomic disparities to help diminish the social gap.

Methods: Analyses were based on 16,838 adults in a community-based cross-sectional survey conducted during 2013-2015 in Henan province, China. Socioeconomic position (SEP) was assessed by education and occupation. Adjusted odds ratios (ORs) were used to calculate the population attributable risk percentage (PAR%) and quantify the mediation of the SEP-hypertension association.

Results: In both genders, obesity, overweight and low fruit intake contributed most to hypertension prevalence (all PAR% were around 20.00%), followed by physical inactivity (PAR% were less than 10%). Substantial social inequalities existed in the prevalence and non-treatment of hypertension, especially for hypertension prevalence in the low (vs. high) educated females (OR: 4.16, 95% confidence interval: 2.71-6.39). Obesity status was the strongest mediator (accounting for 50.00% in males and around 25.00% in females) of the inequalities in hypertension prevalence, followed by fruit intake (explaining 10.13% of the low (vs. high) education, 21.88% of manual (vs. non-manual) workers in females and a vital suppressing effect (-18.18%) of male non-manual (vs. manual) workers related disparities), and physical activity (accounting for 18.18% of male non-manual (vs. manual) workers related disparity).

Conclusion: Weight management and adequate fruit intake may be the most effective approaches to reduce the population risk of hypertension and diminish the social disparities of hypertension in China.

Key Words: hypertension; modifiable risk factor; population attributable risk; socioeconomic disparity

INTRODUCTION

Cardiovascular disease (CVD) is the leading cause of death and hypertension is the strongest preventable risk factor for CVD both in China and worldwide.^{1,2} A national survey in China showed that hypertension accounted for 43.8% of the CVD risk.² Notably, the latest study enrolled around 1.7 million Chinese adults showed that up to 44.7% of the population had hypertension in 2017, of whom only 44.7% were aware of their disease, 30.1% were being treated, and 7.2% had achieved control.³

Lifestyles such as physical inactivity, heavy alcohol intake, smoking, obesity, excess salt intake and low fruit and vegetable intake have been implicated in the etiology of hypertension.⁴ However, there were few studies focused on their public health effects on hypertension. The population attributable risk

percentage (PAR%), based not only on the strength of the risk factor-hypertension relationship but also on the risk factor distributions, gives the percentage of hypertensive attributable to

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the risk factor in the total population, thus can be used to predict the impact of public health interventions on hypertension.⁵

Socioeconomic position (SEP), widely assessed by educational level and occupation, is linked to numerous resources, exposures, and susceptibilities that may affect health.⁶ Previous studies indicated that people of low SEP were associated with high risk of hypertension, which may be partly due to higher exposure of unhealthy lifestyles, however, little evidence existed quantifying the contribution of lifestyle factors to the disparities of hypertension.⁷ In addition, few studies in China have shown unequal distributions of hypertension awareness, treatment, and control existed by SEP.⁸

Accordingly, we did this research to estimate the population risk of hypertension attributable to multiple modifiable vascular risk factors, explore the socioeconomic inequalities in hypertension, and quantify the disparities explained by modifiable risk factors, aiding in the selection of the most effective approaches to prevent hypertension and diminish the socioeconomic disparities of hypertension.

METHODS

Study population

The cross-sectional investigation conducted in Henan province was part of a national survey on the prevalence of major CVD across China from August of 2013 to August of 2015, covering 31 provinces and 262 counties, and supported by the National Key R&D Program during the Twelfth Five-year Plan Period (No.2011BAI11B01). The design has been introduced in detail elsewhere.⁹ Briefly, a multistage stratified random sampling method was adopted to select 19,000 representative samples from the permanent residents aged ≥ 15 years old in Henan province. Using the probability proportional to size method, five urban and six rural areas were randomly selected; then using the simple random sampling method, six urban communities or rural villages were chosen in each sample site.

Data collection

Participants signed the written informed consent were interviewed face-to-face by trained undergraduates and postgraduates, with a standardized questionnaire incorporated data on demographic and other factors, including occupation, education, anthropometric and bioelectrical variables and lifestyles (such as smoking, alcohol consumption, diet, and physical activity).

Participants were reminded of being fasting the day before the survey. Height (0.5-cm precision) and weight (0.1-kg precision) were measured in standing position without shoes and heavy clothing. After resting for 5 minutes, blood pressure (BP) was measured three times with a 30-second interval, using the standardized electronic blood pressure monitors (HBP-1300, OMRON, Kyoto, Japan) at heart level in sitting position.

Definition of terms

Subjects with hypertension were defined as those with mean systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg or regularly receiving antihypertensive medication in recent 2 weeks, according to the Chinese guidelines for the management of hypertension.¹⁰ Unaware and untreated hypertension were defined respectively as among hypertensive a self-reported undiagnosed hypertension, and no regular antihypertensive therapy in recent 2 weeks. Uncontrolled hypertension was defined as treated

hypertensive with systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg.

Education and occupation were the most frequently used indicators of SEP. Education was classified into 3 categories: low (primary school or below), medium (junior high school, senior high school, or secondary vocational and technical education), and high (university or higher). The occupation was dichotomized based on a common classification method as non-manual workers (professionals, managers, government employees, businesspeople or clerks) and manual workers (industrial workers, farmers).¹¹ Smoking was classified based on self-report as never, former and current. Physical activity was dichotomized as inactive vs. active according to the standard scoring methods introduced by Fan et al.,¹² which was based on the metabolic equivalent per week calculated by self-reported types, duration and frequency of work-related, traffic-related and leisure activities. Obesity status was classified based on body mass index (kg/m^2) as normal (< 24), overweight (≥ 24 and < 28), and obesity (≥ 28).¹³ Daily food intake was estimated based on usual frequency and quantity of food consumption during the year preceding enrolment and classified according to the Dietary Guidelines (2016).¹⁴ Briefly, salt intake (g/day) was dichotomized as moderate (0-6) and excess (> 6), vegetable intake (g/day) was classified as lowest (< 150), lower (≥ 150 and < 300) and moderate (≥ 300), fruit intake (g/day) was classified as lowest (< 100), lower (≥ 100 and < 200) and moderate (≥ 200), and alcohol use was dichotomized according to daily ethanol intake (g/day) as heavy (≥ 25 for male and ≥ 15 for female) and not heavy.¹⁴

Statistical analysis

After excluding subjects being pregnant ($n = 39$), aged ≤ 25 years (most of whom have not achieved their final education, $n = 2040$), or missing data on major study variables (education, occupation and BP, $n = 103$), a total of 16,838 participants were included in the study. Data were shown as frequencies (percentages) and compared using Chi-square test. Odds ratios (ORs) and corresponding 95% confidence intervals (95% CIs) were obtained from unconditional logistic regression analyses.

As cross-sectional studies involved no follow-up, hypertension cases in our study were prevalent rather than incident cases so PAR estimates would represent the proportion of prevalent hypertension attributed to exposure and estimate of odds ratio from unconditional logistic regression would be used.^{5,15} As OR was the adjusted odds ratio, the formula of PAR% was recommended as $[P_e \times (OR-1)/OR] \times 100\%$ instead of the usual crude formula, where P_e represented the proportion of the cases of hypertension exposed to each risk factor.¹⁶

When socioeconomic disparities existed in the prevalence of hypertension, the percentage of the inequalities explained by modifiable risk factors, which were associated with hypertension prevalence and differed by SEP, was estimated as: $[(OR_{(\text{confounder adjusted})} - OR_{(\text{confounder and mediator adjusted})}) / (OR_{(\text{confounder adjusted})} - 1)] \times 100\%$.^{17,18}

Statistical analyses were performed using SPSS 21.0 software. Two-sided P values less than 0.05 were considered to be statistically significant.

RESULTS

Characteristics of the participants by SEP

Characteristics of the 16,838 eligible participants by SEP were shown

in Table 1 (7106 males) and Table 2 (9732 females). There were 37.21% (2644) males with hypertension, of whom 44.21% (1169) were unaware of their high BP status and 60.89% (1610) were without regular treatment, and there were 59.96% (620) treated hypertensive uncontrolled of their high BP. For females, the rates of hypertension prevalence, unawareness, non-treatment, and

uncontrolled were 39.57% (3851), 36.59% (1409), 53.73% (2069) and 60.94% (1086), respectively. Furthermore, people of lower SEP (lower educational level and manual workers) showed a higher prevalence of hypertension in both genders and uncontrolled hypertension in females, and males of low educational level showed higher exposure of untreated and uncontrolled hypertension.

Table 1 Characteristics of males according to educational level and occupation, Henan, China, 2013-2015, n (%)

Characteristics	Total	Educational level			Occupation	
		low	medium	high	non-manual	manual
Age (year)		2422(34.08)	3956(55.67)***	728(10.24)***	2466(34.70)	4640(65.30)***
15-44	2053(28.89)	267(11.02)	1292(32.66)	494(67.86)	1079(43.76)	974(20.99)
45-59	2165(30.47)	438(18.08)	1583(40.02)	144(19.78)	766(31.06)	1399(30.15)
60-	2888(40.64)	1717(70.89)	1081(27.33)	90(12.36)	621(25.18)	2267(48.86)
Smoking status		2422(34.08)	3956(55.67)***	728(10.24)***	2466(34.70)	4640(65.30)***
never	2340(32.93)	753(31.09)	1220(30.84)	367(50.41)	903(36.62)	1437(30.97)
former	1224(17.22)	501(20.69)	653(16.51)	70(9.62)	382(15.49)	842(18.15)
current	3542(49.85)	1168(48.22)	2083(52.65)	291(39.97)	1181(47.89)	2361(50.88)
Alcohol use		2422(34.08)	3956(55.67)	728(10.24)**	2466(34.70)	4640(65.30)
not-heavy	6047(85.10)	2043(84.35)	3353(84.76)	651(89.42)	2120(85.97)	3927(84.63)
heavy	1059(14.90)	379(15.65)	603(15.24)	77(10.58)	346(14.03)	713(15.37)
Physical activity		2422(34.08)	3956(55.67)***	728(10.24)***	2466(34.70)	4640(65.30)***
active	4152(58.43)	1397(57.68)	2478(62.64)	277(38.05)	1238(50.20)	2914(62.80)
inactive	2954(41.57)	1025(42.32)	1478(37.36)	451(61.95)	1228(49.80)	1726(37.20)
Salt intake		2422(34.08)	3956(55.67)	728(10.24)	2466(34.70)	4640(65.30)***
moderate	3392(47.73)	930(38.40)	1991(50.33)***	471(64.70)***	1419(57.54)	1973(42.52)
excess	3714(52.27)	1492(61.60)	1965(49.67)	257(35.30)	1047(42.46)	2667(57.48)
Fruit intake		2422(34.08)	3956(55.67)***	728(10.24)***	2466(34.70)	4640(65.30)***
lowest	4366(61.44)	1707(70.48)	2324(58.75)	335(46.02)	1288(52.23)	3078(66.34)
lower	1298(18.27)	377(15.57)	748(18.91)	173(23.76)	523(21.21)	775(16.70)
moderate	1442(20.29)	338(13.96)	884(22.35)	220(30.22)	655(26.56)	787(16.96)
Vegetable intake		2422(34.08)	3956(55.67)***	728(10.24)***	2466(34.70)	4640(65.30)**
lowest	739(10.40)	303(12.51)	358(9.05)	78(10.71)	248(10.06)	491(10.58)
lower	2782(39.15)	1026(42.36)	1512(38.22)	244(33.52)	917(37.19)	1865(40.19)
moderate	3585(50.45)	1093(45.13)	2086(52.73)	406(55.77)	1301(52.76)	2284(49.22)
Obesity Status		2422(34.08)	3956(55.67)***	728(10.24)***	2466(34.70)	4640(65.30)***
normal	2830(39.83)	1118(46.16)	1468(37.11)	244(33.52)	835(33.86)	1995(43.00)
overweight	2967(41.75)	911(37.61)	1715(43.35)	341(46.84)	1111(45.05)	1856(40.00)
obesity	1309(18.42)	393(16.23)	773(19.54)	143(19.64)	520(21.09)	789(17.00)
HT		2422(34.08)	3956(55.67)***	728(10.24)***	2466(34.70)	4640(65.30)***
non-HT	4462(62.79)	1306(53.92)	2613(66.05)	543(74.59)	1625(65.90)	2837(61.14)
HT	2644(37.21)	1116(46.08)	1343(33.95)	185(25.41)	841(34.10)	1803(38.86)
HT awareness		1116(42.21)	1343(50.79)	185(7.00)	841(31.81)	1803(68.19)
aware	1475(55.79)	638(57.17)	744(55.40)	93(50.27)	461(54.82)	1014(56.24)
unaware	1169(44.21)	478(42.83)	599(44.60)	92(49.73)	380(45.18)	789(43.76)
HT treatment		1116(42.21)	1343(50.79)*	185(7.00)	841(31.81)	1803(68.19)
treated	1034(39.11)	462(41.40)	502(37.38)	70(37.84)	328(39.00)	706(39.16)
untreated	1610(60.89)	654(58.60)	841(62.62)	115(62.16)	513(61.00)	1097(60.84)
HT control		462(44.68)	502(48.55)*	70(6.77)	328(31.72)	706(68.28)
controlled	414(40.04)	164(35.50)	219(43.63)	31(44.29)	140(42.68)	274(38.81)
uncontrolled	620(59.96)	298(64.50)	283(56.37)	39(55.71)	188(57.32)	432(61.19)

HT, hypertension.

Symbols denote significant differences from the low educated group or non-manual workers (* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$) with Chi-square test.

Table 2 Characteristics of females according to educational level and occupation, Henan, China, 2013-2015, n (%)

Characteristics	Total	Educational level			Occupation	
		low	medium	high	non-manual	manual
Age (year)		5503(56.55)	3753(38.56)***	476(4.89)***	2100(21.58)	7632(78.42)***
15-44	2005(20.60)	440(8.00)	1167(31.10)	398(83.61)	967(46.05)	1038(13.60)
45-59	3462(35.57)	1544(28.06)	1861(49.59)	57(11.97)	701(33.38)	2761(36.18)
60-	4265(43.82)	3519(63.95)	725(19.32)	21(4.41)	432(20.57)	3833(50.22)
Smoking status		5503(56.55)	3753(38.56)***	476(4.89)	2100(21.58)	7632(78.42)
never	9568(98.31)	5380(97.76)	3716(99.01)	472(99.16)	2070(98.57)	7498(98.24)
former	34(0.35)	29(0.53)	4(0.11)	1(0.21)	6(0.29)	28(0.37)
current	130(1.34)	94(1.71)	33(0.88)	3(0.63)	24(1.14)	106(1.39)
Alcohol use		5503(56.55)	3753(38.56)*	476(4.89)*	2100(21.58)	7632(78.42)
not-heavy	9653(99.19)	5447(98.98)	3730(99.39)	476(100.00)	2082(99.14)	7571(99.20)
heavy	79(0.81)	56(1.02)	23(0.61)	0(0.00)	18(0.86)	61(0.80)
Physical activity		5503(56.55)	3753(38.56)***	476(4.89)***	2100(21.58)	7632(78.42)**
active	6437(66.14)	3621(65.80)	2648(70.56)	168(35.29)	1327(63.19)	5110(66.95)
inactive	3295(33.86)	1882(34.20)	1105(29.44)	308(64.71)	773(36.81)	2522(33.05)
Salt intake		5503(56.55)	3753(38.56)***	476(4.89)***	2100(21.58)	7632(78.42)***
moderate	4661(47.89)	2266(41.18)	2059(54.86)	336(70.59)	1305(62.14)	3356(43.97)
excess	5071(52.11)	3237(58.82)	1694(45.14)	140(29.41)	795(37.86)	4276(56.03)
Fruit intake		5503(56.55)	3753(38.56)***	476(4.89)***	2100(21.58)	7632(78.42)***
lowest	5321(54.68)	3623(65.84)	1581(42.13)	117(24.58)	739(35.19)	4582(60.04)
lower	1932(19.85)	887(16.12)	922(24.57)	123(25.84)	551(26.24)	1381(18.09)
moderate	2479(25.47)	993(18.04)	1250(33.31)	236(49.58)	810(38.57)	1669(21.87)
Vegetable intake		5503(56.55)	3753(38.56)***	476(4.89)***	2100(21.58)	7632(78.42)***
lowest	1140(11.71)	732(13.30)	343(9.14)	65(13.66)	214(10.19)	926(12.13)
lower	4373(44.93)	2610(47.43)	1590(42.37)	173(36.34)	866(41.24)	3507(45.95)
moderate	4219(43.35)	2161(39.27)	1820(48.49)	238(50.00)	1020(48.57)	3199(41.92)
Obesity Status		5503(56.55)	3753(38.56)***	476(4.89)***	2100(21.58)	7632(78.42)***
normal	3466(35.61)	1747(31.75)	1383(36.85)	336(70.59)	979(46.62)	2487(32.59)
overweight	3803(39.08)	2180(39.61)	1510(40.23)	113(23.74)	759(36.14)	3044(39.88)
obesity	2463(25.31)	1576(28.64)	860(22.92)	27(5.67)	362(17.24)	2101(27.53)
HT		5503(56.55)	3753(38.56)***	476(4.89)***	2100(21.58)	7632(78.42)***
non-HT	5881(60.43)	2752(50.01)	2678(71.36)	451(94.75)	1597(76.05)	4284(56.13)
HT	3851(39.57)	2751(49.99)	1075(28.64)	25(5.25)	503(23.95)	3348(43.87)
HT awareness		2751(71.44)	1075(27.91)	25(0.65)	503(13.06)	3348(86.94)
aware	2442(63.41)	1745(63.43)	681(63.35)	16(64.00)	321(63.82)	2121(63.35)
unaware	1409(36.59)	1006(36.57)	394(36.65)	9(36.00)	182(36.18)	1227(36.65)
HT treatment		2751(71.44)	1075(27.91)	25(0.65)	503(13.06)	3348(86.94)
treated	1782(46.27)	1276(46.38)	496(46.14)	10(40.00)	248(49.30)	1534(45.82)
untreated	2069(53.73)	1475(53.62)	579(53.86)	15(60.00)	255(50.70)	1814(54.18)
HT control		1276(71.60)	496(27.83)**	10(0.56)	248(13.92)	1534(86.08)***
controlled	696(39.06)	471(36.91)	220(44.35)	5(50.00)	122(49.19)	574(37.42)
uncontrolled	1086(60.94)	805(63.09)	276(55.65)	5(50.00)	126(50.81)	960(62.58)

HT, hypertension.

Symbols denote significant differences from the low educated group or non-manual workers (* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$) with Chi-square test.

In both genders, participants of lower SEP tended to be older and exposed more often to excess salt intake, low fruit and vegetable intake, while more physical activity (all $P < 0.05$). In addition, females of lower SEP while males of higher SEP tended to be overweight/obesity more often ($P < 0.05$). The frequency of smoking and heavy drinking were higher in people who received less education, and males of manual (vs. non-manual) workers tended to smoke more often ($P < 0.05$).

Association between SEP and hypertension

We further assessed the age-adjusted gender-specific association between SEP and hypertension. As shown in Fig.1, the low and medium (vs. high) educated females had a significantly higher risk

Fig.1 Association between SEP and HT (a), unaware HT (b), untreated HT (c), and uncontrolled HT (d) by gender, Henan, China, 2013-2015. SEP, socioeconomic position; HT, hypertension; OR, odds ratio; CI, confidence interval. ORs were age-adjusted and gender-specific ORs.

Association between potentially modifiable risk factors and hypertension

We additionally estimated the association between potentially modifiable risk factors and hypertension in Table 3. Multivariate unconditional logistic regression analyses showed that physically inactive, low fruit intake, overweight and obesity were significantly related to higher risks of hypertension in both genders. Whereas heavy alcohol use only for males and excess salt intake only for females were found to be related to hypertension.

When combined the association between each risk factor and hypertension with the proportion of the hypertensive population exposed to the risk factor, data indicated that obesity, overweight and low fruit intake contributed most to the population risk of hypertension in both genders, whose PAR% were all around 20%, followed by physically inactive (PAR% was 6.37% for males and

of hypertension (OR: 4.16, 95%CI: 2.71-6.39; OR: 3.10, 95%CI: 2.02-4.75, respectively), while the association was not statistically significant in males. Female manual workers suffered more often from hypertension compared with non-manual workers (OR: 1.32, 95%CI: 1.17-1.49), whereas in males, manual workers showed a lower risk of prevalent hypertension than non-manual workers (OR: 0.82, 95%CI: 0.74-0.92). Furthermore, the low (vs. high) educated males and manual (vs. non-manual) workers in both genders tended to suffer more often from untreated hypertension (OR: 1.64, 95%CI: 1.15-2.33; OR: 1.29, 95%CI: 1.08-1.54; OR: 1.34, 95%CI: 1.11-1.63, respectively). In addition, female manual workers tended to expose more often to uncontrolled hypertension compared with non-manual workers (OR: 1.49, 95%CI: 1.13-1.96).

7.31% for females), heavy alcohol consumption in males (PAR% was 5.19%) and excess salt intake in females (PAR% was 5.71%).

Socioeconomic inequalities in hypertension mediated by modifiable risk factors

We then estimated to what extent the socioeconomic disparities of hypertension (Fig.1) could be explained by the risk factors associated with hypertension in Table 3. Hypertension prevalence differed only by occupation in males and differed by education and occupation in females (Fig.1). Thus we performed mediation in these social disparities in Table 4. Among females, low SEP was associated with increased risks of hypertension (Model 1), which remained significant after adjustment for the mediator(s) (Model 2-8). Obesity status was the strongest mediator, accounting for about 25.00% of the disparities (Model 7), followed by fruit intake,

mediating 10.13% of the low (vs. high) educated group and 21.88% of the manual (vs. non-manual) workers related excess risks of hypertension (Model 6). In addition, salt intake explained 6.25% of the manual (vs. non-manual) workers related higher risk of hypertension (Model 5), whereas adjusting for physical activity increased the ORs of the low and medium (vs. high) education for hypertension, i.e., physically inactive played a suppressing effect (opposite to the total effect) in the low and medium education-related disparities of hypertension (the percentages of excess risks mediated (PERM) were -7.28% and -8.57%, respectively) (Model 4). Obesity status and fruit intake as the top two mediators together contributed to 35.13% of the low (vs. high) education and 50.00% of the manual (vs. non-manual) workers

related excess risk of hypertension for females (Model 8).

For males, obesity status played a dominant role in the non-manual (vs. manual) workers related higher risk of hypertension (PERM was 50.00%), adjusting for which lead to a non-significant association between occupation and hypertension (OR: 1.11, 95% CI: 0.98-1.24) (Model 7). Physical activity also played an important role, which explained 18.18% of the disparity (Model 4). On the contrary, fruit intake had a vital suppressing effect (PERM was -18.18%) (Model 6). Obesity status and physical activity as the top two positive mediators in male non-manual (vs. manual) workers of the excess risk of hypertension, together explained 63.64% of the disparity and led to a non-significant risk between occupation and hypertension (OR: 1.08, 95%CI: 0.96-1.22) (Model 8).

Table 3 Adjusted ORs and PAR% of modifiable risk factors for hypertension by gender, Henan, China, 2013-2015, n (%)

	Males			Females		
	OR (95%CI)	Exposure%	PAR%	OR (95%CI)	Exposure%	PAR%
Smoking status						
never	1.00	32.72		1.00	98.21	
former	1.02(0.87,1.19)	22.20	-	1.71(0.81,3.63)	0.57	-
current	0.91(0.81,1.03)	45.08	-	0.61(0.41,0.90)	1.22	-0.78
Alcohol use						
not-heavy	1.00	82.15		1.00	99.25	
heavy	1.41(1.21,1.63)	17.85	5.19	0.89(0.54,1.48)	0.75	-
Physical activity						
active	1.00	53.82		1.00	63.44	
inactive	1.16(1.05,1.30)	46.18	6.37	1.25(1.13,1.37)	36.56	7.31
Salt intake						
moderate	1.00	44.25		1.00	42.35	
excess	0.99(0.89,1.11)	55.75	-	1.11(1.01,1.21)	57.65	5.71
Fruit intake						
lowest	1.44(1.26,1.66)	66.07	20.19	1.43(1.27,1.60)	63.26	19.02
lower	1.23(1.03,1.46)	16.57	3.10	1.17(1.01,1.35)	17.76	2.58
moderate	1.00	17.36		1.00	18.98	
Vegetable intake						
lowest	0.90(0.75,1.08)	9.64	-	0.95(0.81,1.10)	12.23	-
lower	1.04(0.93,1.16)	40.96	-	1.01(0.92,1.11)	47.34	-
moderate	1.00	49.39		1.00	40.43	
Obesity Status						
normal	1.00	28.03		1.00	23.73	
overweight	2.01(1.78,2.26)	43.49	21.85	1.93(1.73,2.15)	41.37	19.93
obesity	4.87(4.18,5.66)	28.48	22.63	3.20(2.84,3.61)	34.90	23.99

ORs, odds ratios; CI, confidence interval; PAR%, population attributable risk percentage.

ORs are adjusted for age and all the other risk factors in the table except for the risk factor analyzed.

Exposure% were the proportion of the hypertensive cases exposed to each risk factor.

Table 4 Association between SEP and hypertension mediated by each risk factor by gender, Henan, China, 2013-2015, n (%)

	Males				Females			
	Nonmanual (vs. manual)		Low (vs. high)		Medium (vs. high)		Manual (vs. nonmanual)	
	OR (95%CI)	PERM	OR (95%CI)	PERM	OR (95%CI)	PERM	OR (95%CI)	PERM
Model 1	1.22(1.09,1.36)		4.16(2.71,6.39)		3.10(2.02,4.75)		1.32(1.17,1.49)	
Model 2	1.20(1.08,1.35)	-	4.17(2.72,6.40)	-0.32	3.10(2.02,4.75)	0.00	1.32(1.17,1.49)	0.00
Model 3	1.22(1.09,1.36)	0.00	4.17(2.72,6.40)	-	3.10(2.02,4.76)	-	1.32(1.17,1.49)	-
Model 4	1.18(1.06,1.32)	18.18	4.39(2.86,6.73)	-7.28	3.28(2.14,5.04)	-8.57	1.31(1.16,1.49)	3.13
Model 5	1.22(1.09,1.36)	-	4.09(2.66,6.28)	2.22	3.07(2.00,4.71)	1.43	1.30(1.15,1.47)	6.25
Model 6	1.26(1.12,1.41)	-18.18	3.84(2.49,5.90)	10.13	2.97(1.94,4.56)	6.19	1.25(1.10,1.42)	21.88
Model 7	1.11(0.98,1.24)	50.00	3.37(2.18,5.20)	25.00	2.58(1.67,3.98)	24.76	1.24(1.09,1.40)	25.00
Model 8	1.08(0.96,1.22)	63.64	3.05(1.97,4.73)	35.13	2.45(1.58,3.78)	31.00	1.16(1.02,1.32)	50.00

SEP, socioeconomic position (assessed by educational level and occupation); OR, odds ratio; CI, confidence interval; PERM, percentage of the excess risk mediated.

Model 1-8 are the association between SEP and hypertension with and without the hypothesized mediator(s), and PERM, calculated as $[(OR_{Model 1} - OR_{Model 1 + risk factor(s)}) / (OR_{Model 1} - 1)] \times 100\%$ is considered the mediated effect. Model 1: adjusted for age; Model 2-7: adjusted for age plus each hypothesized mediator (smoking status, alcohol use, physical activity, salt intake, fruit intake, and obesity status, respectively), PERM were filled with “-” of the nonsignificant risk factors in table 3; Model 8: adjusted for age plus the top two positive mediators in each disparity simultaneously (obesity status and physical activity for males, obesity status and fruit intake for females).

DISCUSSION

We presented a study assessing the population attributed risk of multiple modifiable vascular risk factors in hypertension prevalence and quantifying the mediation of the risk factors in the SEP-hypertension association. Our findings suggested that obesity, overweight and low fruit intake contributed most to the population risk of hypertension in China. Substantial socioeconomic disparities existed in the prevalence and non-treatment of hypertension. Obesity status was the strongest mediator in both genders, followed by fruit intake of the social inequalities in hypertension prevalence.

Consistent with previous studies that educationally disadvantaged females were the most vulnerable to having hypertension,⁸ our studies showed that the low (vs. high) educated females had approximately 3.2-fold higher risk of hypertension. However, occupation-related disparities in hypertension were evaluated in few studies with conflicting results,⁸ and the present study indicated that non-manual workers in males while manual workers in females showed increased hypertension risks. People of different SEP showing varying risks of hypertension may due to differences in lifestyles, environmental exposure, chronic stress and access to health care, of which lifestyles were the strongest and most preventable contributors.⁶ A few studies have quantified the specific contributions of lifestyle risk factors to the association of education with CVD and other diseases, but only one study in South Africa to our knowledge has estimated the mediation in the SEP-hypertension relationship.⁷ Consistent with the previous study, we found obesity status was the most important mediator and physical activity also played a part in the disparities, however, there was less consistent evidence for other risk factors (i.e. alcohol use, smoking, dietary salt, fruit and vegetable intake), of which fruit intake played a vital role in our study, but it was not analyzed in the previous study.⁷ This may reflect variation in the social patterning of hypertension and the different distributions of potential mediating risk factors across countries.¹⁹

Obesity and overweight remained to be major risk factors for hypertension. Fortunately, a previous prospective cohort study showed that becoming nonobese may reduce the risk of

developing hypertension to a level similar to those who had never been obese.²⁰ With the socioeconomic transitions and lifestyle changes in China, the proportion of obesity and overweight have been rising rapidly, and consistent with previous studies, our study identified obesity and overweight to be the most important contributors to the population risk of hypertension.²¹ In addition, our results indicated that females of lower SEP (lower education and manual workers) while males of higher SEP (higher education and non-manual workers) might expose more often to obesity and overweight, which was in concordance with previous studies in China.²² Thus as can be expected, this study showed that weight was the strongest mediator of the social disparities in hypertension, consistent with the only study analyzing the mediation of the SEP-hypertension relationship.⁷

Low fruit intake as an important risk factor for CVD has been paid more and more attention these years, but the overall consumption was still in severe shortage and it was one of the three leading dietary risk factors for deaths globally in 2017.^{23,24} Few studies have quantified the PAR of lifestyle risk factors for hypertension, and the PAR of dietary fruit intake was rarely mentioned.^{5,21} It was surprising to find that the lowest fruit intake showed even equal PAR% of around 20% as obesity and overweight presented. Consistent with previous studies, individuals of lower SEP showed a significantly higher exposure of low fruit intake in this study,²⁵ thus fruit intake might be an important mediator of the SEP-hypertension relationship, and our study verified this hypothesis, notably that fruit intake mediated around 22% of the manual (vs. non-manual) workers related excess risk of hypertension. Further large cohort studies are needed to confirm the effect of fruit intake on the population risk and the socioeconomic disparities of hypertension.

To the best of our knowledge, this was the first study that systematically assessed the population risk of hypertension attributable to multiple modifiable vascular risk factors and quantified the mediation effect of the socioeconomic inequalities in hypertension in China. The large sample population-based survey data based on well designed and implemented national project was an advantage of this study.

Meanwhile, there were several limitations. One was that some biases existed because a cross-sectional design made it less powerful in causal inference. However, our sampling ensured a representative sample, which might make a meaningful contribution. Moreover, since the study was limited to a single province of China, further prospective studies of different ethnicities were needed to verify our findings.

CONCLUSIONS

In conclusion, this large population-based cross-sectional study in China indicated that substantial socioeconomic disparities existed mainly in hypertension prevalence, especially for females. Weight management and adequate fruit intake may be the most effective approaches that could reduce the population risk of hypertension and diminish the socioeconomic disparities of hypertension in China. Further large-scale prospective studies are needed to support our findings, thereby providing evidence for the public health interventions on hypertension.

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Disclosure statement

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