Association of Husband Smoking With Wife's Hypertension Status in Over 5 Million Chinese Females Aged 20 to 49 Years

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Background—The effect of second-hand smoking, especially husband smoking, on wife's hypertension has not been well studied. The current study was aimed to assess the association of husband smoking with wife's hypertension among females aged 20 to 49 years.

Methods and Results—This study included 5 027 731 females along with their husbands from the National Free Pre-pregnancy Checkup Projects conducted across 31 provinces in China in 2014. Smoking/passive smoking status was collected by a standard questionnaire and blood pressure was measured by an electronic device after 10 minutes rest. Odds ratios and their corresponding 95% CIs for female hypertension were estimated according to smoking status of husband and wife, husbands' smoking amount, and cumulative exposure to husband smoking. Compared with neither-smoker group, the multivariable-adjusted odds ratio for female hypertension was 1.28 (1.27–1.30), 1.53 (1.30–1.79), and 1.50 (1.36–1.67) in husband-only, wife-only, and mixed group, respectively. Furthermore, a higher risk of having hypertension was associated with amount and cumulative exposure of husband smoking. For example, compared with neither-smoker, the multivariate-adjusted odds ratio was 1.22 (1.19–1.25), 1.24 (1.21–1.26), 1.32 (1.26–1.37), 1.37 (1.34–1.41), and 1.75 (1.64–1.87) for females whose husband smoked 1 to 5, 6 to 10, 11 to 15, 16 to 20, and ≥21 cigarettes per day, respectively ($P_{for\ trend}$<0.001). Subgroup analyses identified similar results.

Conclusions—There were associations of husband smoking with female hypertension prevalence. A family-based smoking restriction strategy may reduce smoking in males and improve hypertension control in females. (***J Am Heart Assoc***. 2017;6: e004924. DOI: 10.1161/JAHA.116.004924.)

Key Words: China • cross-sectional study • hypertension • passive smoking

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As the leading risk factor for global burden of disease and global mortality, the prevalence of high blood pressure (BP) has been expected to increase over the next decade worldwide.[1,2] In 2010, the prevalence of hypertension was about 26.7% among the Chinese population aged 20 years and older, and that in women has reached 24.5%.[3] Although 31% to 68% of BP variation in the population may be genetically determined,[4] the small aggregate effect of identified genetic loci has limited its applicability to hypertension prevention.[5] Therefore, environmental factors, also important in causing high BP, are critical in the management, prevention, and control of hypertension.

Nonpharmacological management of hypertension, including smoking cessation, weight reduction, and a healthy dietary

pattern with low sodium, low fat, and high fresh fruit and vegetable intake and physical activities, have been recommended in the most recent hypertension guidelines from the United States, the United Kingdom, Europe, and China.[6–9] Tobacco smoking is one of the leading risk factors for disease burden in China and worldwide.[10] Globally, 35% of women nonsmokers were exposed to second-hand smoke, and 47% of deaths from second-hand smoke occurred in women in 2004.[11] In China, an estimate of only 2.4% adult women were smokers and over 740 million nonsmokers were exposed to second-hand smoke,[12,13] which means passive smoking is a more serious public health problem than active smoking in women in countries where the prevalence of women smoking is low. Studies of health consequences of passive smoking in China, a country where the prevalence of tobacco use in men is one of the highest in the world,[13] have critical implications.

Active and passive smoking has been established as a risk factor for all causes of mortality and several chronic diseases, including coronary heart disease and stroke,[14–16] and active smoking is identified as a risk factor for hypertension by abundant evidence.[17] However, whether exposure to second-hand smoking, especially husband smoking, increases the risk of hypertension of females remains unclear. Several studies have investigated the effect of passive smoking on hypertension, but their generalities were limited by small sample size or restriction of only rural participants.[18–20] It is noteworthy that women in China are exposed to tobacco smoke more frequently at home than at workplaces.[13] Therefore, evidence on the association of husband smoking with wife's hypertension will be helpful for hypertension prevention in Chinese women.

The current study aimed to assess the association between husband smoking and wife's hypertension among over 5 million couples in a cross-sectional study based on the National Free Pre-pregnancy Checkups Project (NFPCP) in 2014.

Methods

Participants

The NFPCP is a national health service for reproductive-aged couples who plan to conceive in 6 months. Since 2010, the NFPCP has been supported by the National Health and Family Planning Commission and the Ministry of Finance of the People's Republic of China. Detailed design, organization, and implementation of this project are described elsewhere.[21] The NFPCP started with serving only rural married couples between 2010 and 2012 and after 2013, the services were extended to both rural and urban married couples. Women aged 20 to 49 years old were eligible for this service, and no age limitation was set for men. In 2014, the NFPCP has

served couples from 2907 counties/districts across 31 provinces in Mainland China. Through health education and advocacy by residents' committee, eligible couples were encouraged to participate in the NFPCP services together in local family planning service agencies or maternal and child care service centers.

The current study was based on the health examination data of the NFPCP from January 1 to December 31, 2014. A total of 5 537 307 eligible couples participated in the NFPCP in 2014. We then further excluded participants with missing information on BP or smoking status, as well as those with heart disease, chronic kidney disease, diabetes mellitus, or thyroid diseases. Finally, 5 027 731 couples were included in the current analysis. Detailed information on the study population recruitment is shown in Figure 1.

Data Collection

A face-to-face interview and medical examination were conducted by trained healthcare staff. Demographic characteristics and lifestyle information were collected by questionnaires for husband and wife, separately. "Did you smoke?" and "Are you exposed to passive smoking?" were asked to identify active and passive smoking status of husbands and
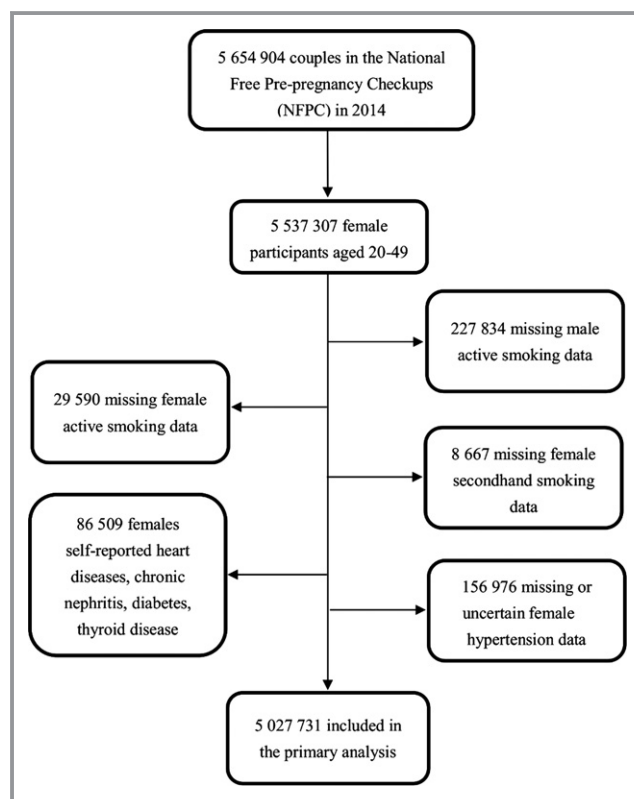
Figure 1. Selection of couples for examining association of husband smoking with wife's hypertension.

wives. Furthermore, smoking amount (cigarettes per day) was collected if they replied "yes" to the first question and the duration of exposure to passive smoking (minutes per day) was also collected if they replied "often" to the second question. Other survey variables included women's alcohol consumption and hypertension history, education level, and urban/rural inhabitants according to the address of household registration; vegetable consumption and meat/egg consumption were also collected. All data were uploaded and transferred remotely and stored in the NFPCP medical service information system, which was supported by the National Research Institute for Family Planning. This study was approved by the Institutional Research Review Board at the National Health and Family Planning Commission. Informed consents were obtained from all the NFPCP participants.

Exposure and Outcome

Smoking was defined as ≥1 cigarette smoking per day for at least 1 year at the time of examination. Second-hand smoking exposure was defined as exposure to environmental tobacco smoke every day. Duration of marriage was the interval years between marriage year and the examination year, which is 2014. Body weight and height were measured with light indoor clothes without shoes and other accessories. Body mass index (BMI) was calculated as kilograms per square meters (kg/m^2). According to smoking status of both husband and wife, 5 027 731 couples were divided into 4 groups: (1) neither wife nor husband smoked (neither-smoker), (2) only the husband smoked (husband-only), (3) only the wife smoked (wife-only), and (4) both smoked (mixed). Based on husbands' smoking amount, we also split the couples into 6 groups (0, 1–5, 6–10, 11–15, 16–20, and ≥21 cigarettes per day). In addition, with the purpose of evaluating the cumulative effect of husband smoking on wife's hypertension, we calculated "pack-marriage year" by multiplying the number of packs of cigarettes husband smoked per day by the number of marriage duration, which is similar to "pack-year." For example, 1 pack-marriage years is equal to husbands' smoking 20 cigarettes (1 pack) per day for 1 year of marriage, or 40 cigarettes (2 packs) per day for half a year of marriage. All couples were divided into 6 groups according to pack-marriage year (0, 0.1–2.0, 2.1–4.0, 4.1–6.0, 6.1–8.0, and >8.0 pack-marriage years).

By following the standard protocol entitled "Guidelines for Physical Examination of the NFPCP," physicians conducted BP measurement in the right arm of the participants using an automated BP monitor, on a single occasion after participants rested for at least 10 minutes. As the main outcome of this study, hypertension status in women is determined by the combined information of self-reported hypertension history and seated BP measurement. Hypertension was defined as systolic BP/diastolic BP ≥140/90 mm Hg or self-reported hypertension history.

Statistical Analysis

Baseline characteristics were presented as mean (SD) or median (interquartile range) for continuous variables, and number (percentages) for categorical variables according to BP status, respectively. Differences of baseline characteristics between BP groups were examined using independent *t* tests or Wilcoxon rank sum tests for continuous variables and χ^2 tests for categorical variables, respectively.

We estimated the odds ratios (ORs) and their corresponding 95% CIs of hypertension associated with smoking status of couples (neither-smoker, husband-only, wife-only, and mixed group), husband smoking amount (0, 1–5, 6–10, 11–15, 16–20, and ≥21 cigarettes per day), and the cumulative exposure to husband smoking (0, 0.1–2.0, 2.1–4.0, 4.1–6.0, 6.1–8.0, and >8.0 pack-marriage years) using an age-adjusted and multivariate-adjusted logistic regression model, respectively. A total of 5 027 731 couples were used to examine the association between couples smoking status and hypertension, and 15 753 couples from the wife-only group or mixed group were excluded from the analyses on association of husband smoking amount or cumulative exposure to husband smoking with hypertension. Furthermore, 621 776 couples with missing marriage duration were also excluded from the analysis on association of cumulative exposure to husband smoking with hypertension. Covariates in the multivariate-adjusted logistic regression model included age, high school education, urban inhabitants, BMI, and alcohol consumption. Subgroup analyses were performed according to the duration of husband smoking exposure (minutes per day), education levels, living area (urban/rural), alcohol consumption, and the BMI category, respectively. The current study incorporated a wide range of Chinese ethnicities including Han, Uygur, Zhuang, Hui, Miao, Tujia, Yi, Mongolia, Manchu, Tibetan, and others. The Chinese Han population accounted for 87.8% of the total study population. Subgroup analysis was also conducted taking the impact of sodium intake on BP into consideration.[22] Participants were classified into 3 groups according to sodium intake condition of different provinces, including provinces with less sodium intake (group 1=Sichuan, Guangdong, Jiangxi, Ningxia, Jilin, Shanghai, Inner Mongolia, Heilongjiang, and Liaoning), excessive sodium intake provinces (group 2=Jiangsu, Zhejiang, Qinghai, Hubei, Hebei, Shaanxi, Hunan, Fujian, Henan, Guangxi, and Beijing), and sodium intake unavailable provinces (group 3=Tianjin, Anhui, Shandong, Hainan, Chongqing, Guizhou, Yunnan, Tibetan, Shanxi, Gansu, and Sinkiang). We

Table 1. Characteristics of Female Participants According to Blood Pressure Status From 5 027 731 Couples

Variables	Normotensive	Hypertensive	P Value
N	4 933 181	94 550	…
Age, y			<0.0001
20 to 24	1 971 069 (39.96)	26 787 (28.33)	
25 to 29	1 979 067 (40.12)	32 639 (34.52)	
30 to 34	664 997 (13.48)	17 964 (19.00)	
35 to 39	231 436 (4.69)	10 543 (11.15)	
≥40	86 612 (1.76)	6617 (7.00)	
Nationality, n (%)			<0.0001
Han	4 332 198 (88.95)	80 695 (86.21)	
Others	538 388 (11.05)	12 903 (13.79)	
Urban inhabitants, n (%)	396 603 (8.04)	8743 (9.25)	<0.0001
Higher education, n (%)	1 568 691 (32.7)	25 961 (28.17)	<0.0001
Marriage duration (y)*, median (IQR)	1 (0–4)	3 (0–7)	<0.0001
BMI (kg/m^2)			<0.0001
Underweight (<18.5)	642 793 (13.05)	7944 (8.42)	
Normal weight (18.5-)	3 488 821 (70.84)	50 805 (53.86)	
Overweight (24.0-)	640 849 (13.01)	22 773 (24.14)	
Obese (28.0-)	152 525 (3.10)	12 812 (13.58)	
Alcohol consumption, n (%)	144 316 (2.93)	3658 (3.88)	<0.0001
Smoking amount (cigarettes per day), n (%)			<0.0001
0	4 918 004 (99.69)	93 974 (99.39)	
1 to 5	7889 (0.16)	264 (0.28)	
6 to 10	4628 (0.09)	189 (0.20)	
11 to 15	2532 (0.05)	121 (0.13)	
Duration of second-hand smoking exposure (minutes/day), n (%)			<0.0001
0	4 399 820 (95.73)	80 461 (93.25)	
1 to 15	124 287 (2.70)	3199 (3.71)	
≥16	72 153 (1.57)	2622 (3.04)	
Smoking status of couples, n (%)			<0.0001
Neither-smoker	3 531 347 (71.58)	61 343 (64.88)	
Husband-only	1 386 657 (28.11)	32 631 (34.51)	
Wife-only	4189 (0.08)	172 (0.18)	
Mixed	10 988 (0.22)	404 (0.43)	
Husband smoking amount (cigarettes per day), n (%)			<0.0001
0	3 535 536 (71.67)	61 515 (65.06)	
1 to 5	339 318 (6.88)	7076 (7.48)	
6 to 10	609 206 (12.35)	13 310 (14.08)	
11 to 15	113 207 (2.29)	2700 (2.86)	
16 to 20	313 259 (6.35)	8968 (9.48)	
≥21	22 655 (0.46)	981 (1.04)	

Table 1. Continued

Variables	Normotensive	Hypertensive	P Value
Cumulative exposure of husband smoking (pack-marriage years)[†], n (%)			<0.0001
0	3 750 871 (84.89)	65 502 (76.7)	
0.1 to 2.0	376 222 (8.51)	8350 (9.78)	
2.1 to 4.0	141 110 (3.19)	4186 (4.90)	
4.1 to 6.0	65 963 (1.49)	2366 (2.77)	
6.1 to 8.0	31 813 (0.72)	1432 (1.68)	
>8.0	52 537 (1.19)	3568 (4.18)	

BMI indicates body mass index; IQR, interquartile range.

*Duration of marriage was defined as the interval years between marriage year and the examination year.

[†]Pack-marriage years were used to evaluate the cumulative exposure of spouse smoking, calculated by multiplying the number of packs of cigarettes husband smoked per day by the number of marriage duration.

also conducted sensitivity analyses restricting the population from the same specific ethnicities, couples where wives were without known hypertension, and couples with marriage duration of ≥2 years. Additionally, sensitivity analysis was also conducted by excluding women who did not like vegetables and those who were vegetarian.

Table 2. Association Between Exposure Measurements and Prevalent Hypertension of Female Participants

Exposure Measurements	Age-Adjusted		Multivariate-Adjusted*	
	N (%)	OR (95% CI)	N (%)	OR (95% CI)
Couples smoking status				
Neither-smoker	3 592 690 (1.71)	1.00	3 476 410 (1.71)	1.00
Husband-only	1 419 288 (2.30)	1.35 (1.33–1.36)	1 379 157 (2.31)	1.28 (1.27–1.30)
Wife-only	4361 (3.94)	1.84 (1.58–2.15)	4203 (3.88)	1.53 (1.30–1.79)
Mixed	11 392 (3.55)	1.76 (1.60–1.95)	10 972 (3.63)	1.50 (1.36–1.67)
Husbands' smoking amount[†]				
0	3 592 690 (1.71)	1.00	3 476 410 (1.71)	1.00
1 to 5	344 356 (2.04)	1.26 (1.22–1.29)	333 811 (2.03)	1.22 (1.19–1.25)
6 to 10	618 257 (2.13)	1.28 (1.26–1.31)	600 548 (2.14)	1.24 (1.21–1.26)
11 to 15	114 818 (2.32)	1.37 (1.32–1.42)	111 745 (2.32)	1.32 (1.26–1.37)
16 to 20	318 620 (2.77)	1.48 (1.45–1.52)	310 371 (2.79)	1.37 (1.34–1.41)
≥21	23 237 (4.14)	1.94 (1.81–2.07)	22 682 (4.16)	1.75 (1.64–1.87)
$P_{for\ trend}$	<0.0001	<0.0001	<0.0001	<0.0001
Cumulative exposure of Spouse smoking[‡§]				
0	3 807 995 (1.71)	1.00	3 731 435 (1.71)	1.00
0.1 to 2.0	382 046 (2.16)	1.34 (1.31–1.37)	376 515 (2.15)	1.23 (1.20–1.26)
2.1 to 4.0	144 216 (2.87)	1.49 (1.44–1.54)	142 135 (2.85)	1.36 (1.32–1.41)
4.1 to 6.0	67 739 (3.46)	1.53 (1.47–1.60)	66 801 (3.45)	1.40 (1.35–1.47)
6.1 to 8.0	32 932 (4.29)	1.63 (1.54–1.72)	32 469 (4.29)	1.50 (1.42–1.59)
>8.0	55 274 (6.35)	1.79 (1.72–1.85)	54 532 (6.35)	1.63 (1.56–1.68)
$P_{for\ trend}$	<0.0001	<0.0001	<0.0001	<0.0001

OR indicates odds ratio.

*Adjusted for age, urban inhabitants, higher school education, body mass index, and alcohol consumption.

[†]After excluding 15 753 couples from the analysis because of female active smoking, 5 011 978 couples remained in this analysis.

[‡]Cumulative exposure of Spouse smoking was defined by pack-marriage year to evaluate the cumulative exposure of spouse smoking, calculated by multiplying the number of packs of cigarettes husband smoked per day by the number of marriage duration.

[§]After excluding 15 753 couples from the analysis because of female active smoking and 621 776 couples missing marriage duration, 4 390 202 couples remained in this analysis.

We further conducted dose–response analyses on the association of husband smoking and hypertension prevalence based on the husband smoking amount and the cumulative exposure to husband smoking. By treating a categorical variable as an ordinal variable in the regression model, we tested the significance of the linear trend. The R software (version 3.2.2; https://www.r-project.org/) was used for all analyses. The Speedglm package (version 0.3–1) was used for fitting logistic regression modeling with large data sets by updating algorithms.

Results

Among 5 027 731 women aged 20 to 49 years recruited in 2014, the prevalence of hypertension is 1.88%. Among 94 550 hypertensive patients, 92 549 were defined by BP measurement, 3983 were defined by self-reported hypertension history, and 1982 were self-reported hypertensive patients with systolic BP/diastolic BP ≥140/90 mm Hg during the physical examination. The characteristics of women are presented according to their hypertension status (Table 1). Women with hypertension were more likely to be older, urban inhabitants, and with less educational attainment, compared to the women without hypertension. They were also more likely to drink alcohol and have higher BMIs than those who were not hypertensive. Particularly, women with hypertension had longer marriage duration, larger probability of exposure to husband smoking, and longer duration of second-hand smoking exposure than those in the normotensive group.

Among 5 027 731 couples, 28.23% of them (1 419 288 couples) were classified into the husband-only group. The hypertension prevalence of women was 1.71%, 2.30%, 3.94%, and 3.55% in the neither-smoker, husband-only, wife-only, and

Table 3. Subgroup Analyses on Associations Between Husband Smoking and Prevalent Hypertension Among Females

Subgroup	Neither-Smoker		Husband-Only		Multivariate-Adjusted OR* (95% CI)
	No. of Participants	No. of Hypertension (%)	No. of Participants	No. of Hypertension (%)	
Age, y					
20 to 24	1 317 255	16 512 (1.25)	496 225	7551 (1.52)	1.16 (1.13–1.19)
25 to 29	1 338 749	19 750 (1.48)	463 824	8929 (1.93)	1.21 (1.18–1.24)
30 to 34	447 925	10 477 (2.34)	163 527	5181 (3.17)	1.25 (1.20–1.29)
35 to 39	156 924	5967 (3.80)	60 497	3207 (5.30)	1.29 (1.23–1.35)
≥40	60 104	3630 (6.04)	23 846	2123 (8.90)	1.37 (1.29–1.45)
Second-hand smoking, minutes per day					
0	3 256 825	54 743 (1.68)	1 080 787	23 117 (2.14)	1.22 (1.20–1.24)
1 to 15	43 930	991 (2.26)	75 578	2040 (2.63)	1.12 (1.03–1.21)
≥16	20 202	602 (2.98)	49 554	1834 (3.70)	1.20 (1.09–1.32)
Higher school education					
Yes	1 134 542	17 132 (1.50)	447 119	8543 (1.91)	1.21 (1.18–1.24)
No	2 341 868	42 219 (1.80)	932 038	23 247 (2.49)	1.32 (1.29–1.34)
Urban inhabitants					
Yes	265 128	5167 (1.95)	114 362	2939 (2.57)	1.22 (1.16–1.27)
No	3 211 282	54 184 (1.69)	1 264 795	28 851 (2.28)	1.29 (1.27–1.31)
Drinking					
Yes	76 268	1660 (2.18)	76 268	1660 (2.18)	1.17 (1.09–1.25)
No	3 400 142	57 691 (1.70)	1 318 465	30 148 (2.29)	1.29 (1.27–1.31)
BMI category†					
Underweight	425 212	4918 (1.16)	200 708	2748 (1.37)	1.17 (1.12–1.23)
Normal weight	2 501 460	33 159 (1.33)	928 725	15 872 (1.72)	1.29 (1.26–1.31)
Overweight	444 280	13 795 (3.11)	198 725	8237 (4.14)	1.33 (1.29–1.36)
Obesity	105 458	7479 (7.09)	54 999	4933 (8.97)	1.28 (1.24–1.33)

BMI indicates body mass index; OR, odds ratio.
*Adjusted for age, urban inhabitants, higher school education, BMI, and alcohol consumption.
†Females with BMI ≤18.0, 18.0 to 23.9, 24.0 to 27.9, and ≥28.0 kg/m² were defined as underweight, normal weight, overweight, and obese.

mixed group, respectively. Compared with couples where neither spouse smoked, the multivariate-adjusted OR for hypertension among women was 1.28 (95% CI: 1.27–1.30), 1.53 (95% CI: 1.30–1.79), and 1.50 (95% CI: 1.36–1.67) in the husband-only, wife-only, and mixed group, respectively, which implied a significant adverse effect of husband smoking on wife's hypertension (Table 2). In addition, subgroup analyses revealed that the associations between husband smoking and wife's hypertension were consistent across all subgroups (Table 3). It is interesting that although wives did not report second-hand smoking exposure, those in the husband-only group were still at an increased risk of hypertension, with the multivariate-adjusted OR being 1.22 (95% CI: 1.20–1.24) (Table 3).

The hypertension prevalence in women showed significant linear trends with husband smoking amount (Table 2). Using neither-smoker group as the reference group, the multivariate-adjusted ORs of hypertension among women were 1.22 (95% CI: 1.19–1.25), 1.24 (95% CI: 1.21–1.26), 1.32 (95% CI: 1.26–1.37), 1.37 (95% CI: 1.34–1.41), and 1.75 (95% CI: 1.64–1.87) for women whose husband smoked 1 to 5, 6 to

10, 11 to 15, 16 to 20, and ≥21 cigarettes per day, respectively ($P_{for\ trend}<0.001$). Consistent results and similar linear trends were also obtained across all subgroup analyses according to age, duration of second-hand smoking exposure, education level, living area (urban/rural), alcohol consumption, and BMI category (Figure 2, $P_{for\ trend}<0.001$). In addition, increases in both duration of second-hand smoking exposure and husband smoking amount were associated with substantially increased risk of hypertension. Similar results were also observed for combined groups of duration of second-hand smoking with husband smoking amount or cumulative exposure to husband smoking, as well as of BMI categories with the aforementioned 2 indicators (Tables 4 and 5).

As shown in Table 2, the risk of having hypertension in women increased with the increment of cumulative exposure, and the multivariate-adjusted ORs were 1.23 (95% CI: 1.20–1.26), 1.36 (95% CI: 1.32–1.41), 1.40 (95% CI: 1.35–1.47), 1.50 (95% CI: 1.42–1.59), and 1.63 (95% CI: 1.56–1.68) in the group with cumulative exposure of 0.1 to 2.0, 2.1 to 4.0, 4.1 to 6.0, 6.1 to 8.0, and >8.0 pack-marriage years ($P_{for\ trend}<0.001$), respectively, when comparing those who
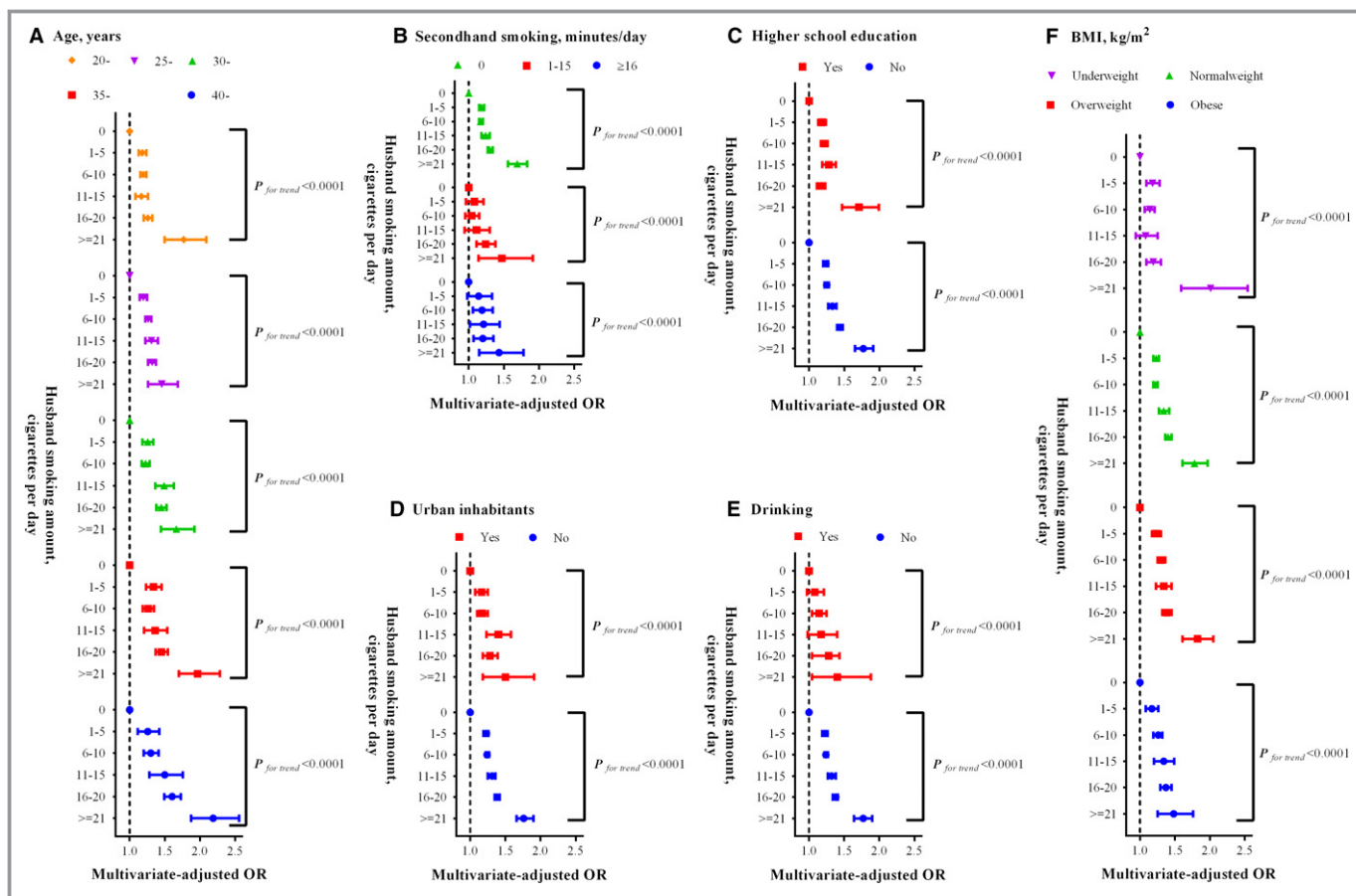
Figure 2. Subgroup analyses on association between husband smoking amount and prevalent hypertension in women. (A), Age, years; (B) second-hand smoking, minutes/day; (C) higher school education; (D) urban inhabitants; (E) drinking; (F) BMI, kg/m². BMI indicates body mass index; OR, odds ratio.

Table 4. Odds Ratios* (95% CI) for Female Hypertension in Females With Different Husband Smoking Amount According to Second-Hand-Smoking Duration and BMI Category

Group	Husband Smoking Amount (Cigarettes Per Day)					
	0	1 to 5	6 to 10	11 to 15	16 to 20	≥21
Second-hand smoking duration, minutes per day						
0	1.00	1.18 (1.15–1.22)	1.17 (1.15–1.20)	1.24 (1.18–1.30)	1.30 (1.27–1.34)	1.69 (1.56–1.83)
1 to 15	1.30 (1.22–1.38)	1.39 (1.26–1.53)	1.34 (1.24–1.44)	1.43 (1.23–1.66)	1.63 (1.50–1.77)	1.99 (1.55–2.55)
≥16	1.53 (1.41–1.66)	1.72 (1.51–1.96)	1.82 (1.68–1.97)	1.85 (1.59–2.15)	1.88 (1.73–2.04)	2.26 (1.85–2.76)
BMI category†						
Underweight	0.96 (0.94–0.99)	1.14 (1.06–1.23)	1.11 (1.05–1.17)	1.06 (0.92–1.21)	1.17 (1.08–1.27)	1.97 (1.57–2.49)
Normal weight	1.00	1.22 (1.18–1.27)	1.22 (1.19–1.25)	1.34 (1.27–1.42)	1.41 (1.36–1.45)	1.78 (1.61–1.97)
Overweight	2.14 (2.09–2.18)	2.63 (2.50–2.77)	2.78 (2.68–2.88)	2.85 (2.63–3.09)	2.96 (2.83–3.09)	3.92 (3.48–4.42)
Obese	5.12 (4.99–5.26)	6.13 (5.73–6.56)	6.48 (6.18–6.81)	6.91 (6.22–7.68)	6.91 (6.54–7.29)	7.37 (6.23–8.73)

BMI indicates body mass index.
*Adjusted for age, urban inhabitants, higher school education, BMI, and alcohol consumption.
†Females with BMI ≤18.0, 18.0 to 23.9, 24.0 to 27.9, and ≥28.0 kg/m^2 were defined as underweight, normal weight, overweight, and obese.

were not exposed to husband smoking. Subgroup analyses generated similar results and linear trends (Figure 3).

In the subgroup analyses restricting to specific ethnicity (including Han, Uygur, Zhuang, Hui, Miao, Tujia, Yi, Mongolia, Manchu, Tibetan, and others), hypertension among women was associated with husband smoking in both categorical and dose–response manners (Table 6). To enhance our findings, provincial analyzed sodium intake was also taken into consideration for subgroup analysis, and the result showed that female hypertension was significantly associated with husband smoking of different measurement in all subgroups (Table 7).

To test the robustness of our findings, we excluded women with hypertension history, couples with marriage duration of less than 2 years, women who did not like vegetables, and those who were vegetarian, respectively, and found that the results were not substantially changed (Table 8).

Discussion

In this large cross-sectional study incorporating over 5 million married couples in both urban and rural China, we identified that husband smoking was significantly associated with

Table 5. Odds Ratios* (95% CI) for Female Hypertension in Females With Different Cumulative Exposure of Husband Smoking According to Second-Hand-Smoking Duration and BMI Category

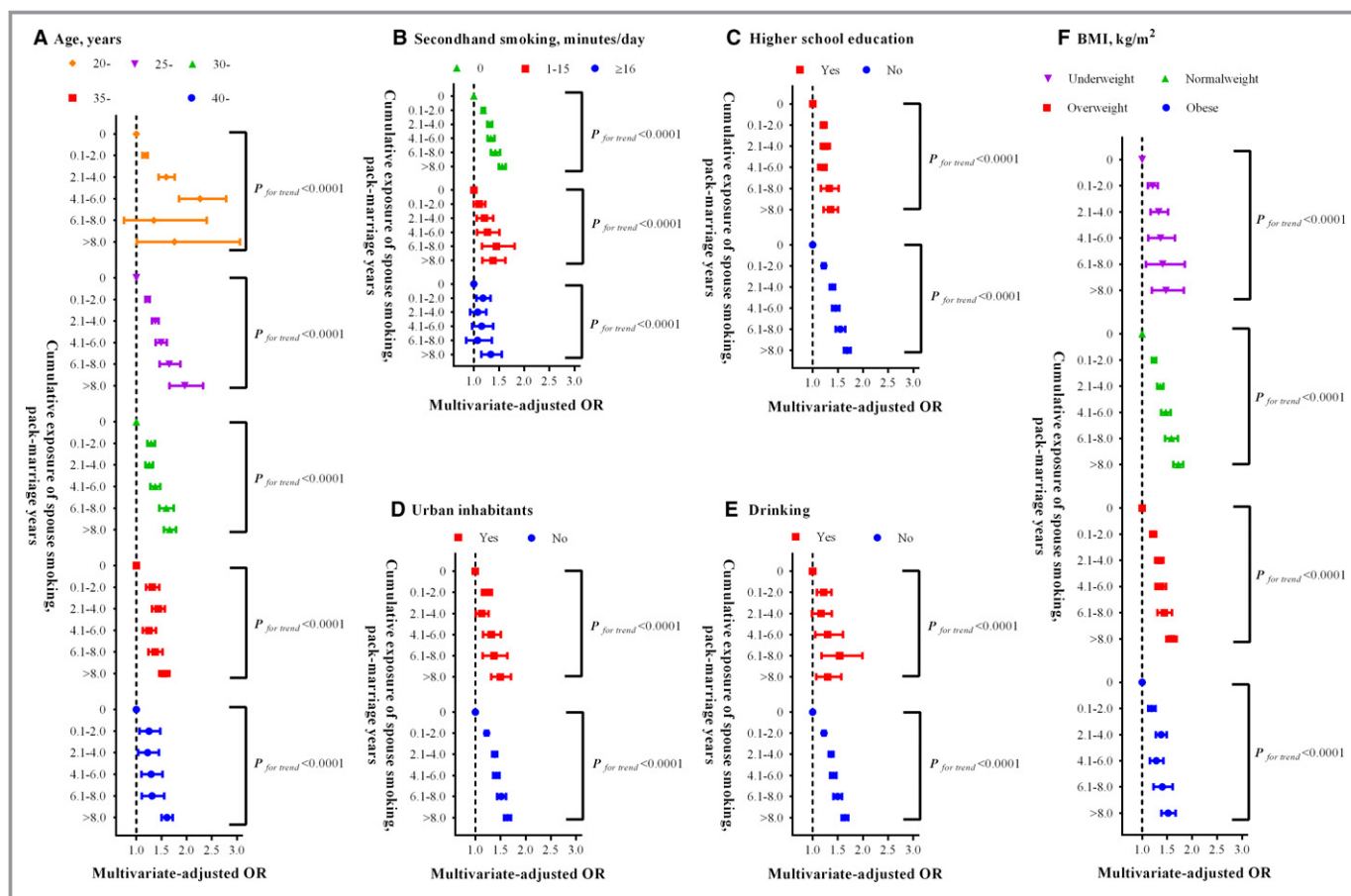| Group	Cumulative Exposure of Husband Smoking (Pack-Marriage Years)†					
	0	0.1 to 2.0	2.1 to 4.0	4.1 to 6.0	6.1 to 8.0	>8.0
Second-hand smoking, minutes per day						
0	1.00	1.19 (1.16–1.22)	1.32 (1.27–1.37)	1.34 (1.27–1.41)	1.43 (1.33–1.52)	1.56 (1.49–1.63)
1 to 15	1.24 (1.18–1.31)	1.38 (1.26–1.51)	1.55 (1.37–1.75)	1.65 (1.41–1.94)	1.90 (1.55–2.34)	1.87 (1.64–2.15)
≥16	1.59 (1.49–1.69)	1.91 (1.73–2.11)	1.80 (1.57–2.05)	1.96 (1.66–2.31)	1.85 (1.48–2.30)	2.33 (2.06–2.62)
BMI category‡						
Underweight	0.95 (0.92–0.98)	1.16 (1.07–1.25)	1.26 (1.11–1.44)	1.29 (1.07–1.56)	1.33 (1.02–1.74)	1.43 (1.17–1.75)
Normal weight	1.00	1.24 (1.20–1.28)	1.36 (1.29–1.42)	1.46 (1.38–1.56)	1.57 (1.45–1.70)	1.72 (1.63–1.82)
Overweight	2.17 (2.13–2.21)	2.62 (2.51–2.74)	2.93 (2.76–3.12)	3.02 (2.80–3.27)	3.21 (2.91–3.54)	3.55 (3.34–3.77)
Obese	5.21 (5.08–5.35)	6.31 (5.97–6.67)	7.20 (6.68–7.76)	6.65 (5.99–7.37)	7.14 (6.24–8.16)	7.32 (6.71–7.99)

BMI indicates body mass index.
*Adjusted for age, urban inhabitants, higher school education, BMI, and alcohol consumption.
†Pack-marriage year were used to evaluate the cumulative exposure of spouse smoking, calculated by multiplying the number of packs of cigarettes husband smoked per day by the number of marriage duration.
‡BMI ≤18.0, 18.0 to 23.9, 24.0 to 27.9, and ≥28.0 kg/m^2 was defined as underweight, normal weight, overweight, and obese.

Figure 3. Subgroup analyses on association between cumulative exposure of husband smoking and prevalent hypertension in women. (A), Age, years; (B) second-hand smoking, minutes/day; (C) higher school education; (D) urban inhabitants; (E) drinking; (F) BMI, kg/m². BMI indicates body mass index; OR, odds ratio.

increased prevalence of hypertension among their wives, consistently in categorical, dose–response, and cumulative manners. It is noteworthy to point out that the associations persisted in the subgroup analyses by the duration of husband smoking exposure, the women's education level, alcohol consumption, and BMI categories, as well as the couples' living areas (urban/rural).

The relationship between active smoking and hypertension has been clarified in men and women,[23,24] but only a few studies explored the effect of passive smoking on hypertension. After conducting a systematic review, 13 studies were conducted to investigate the association of passive smoking with hypertension or BP.[18–20,25–34] Among these, 4 examined the association among infants or adolescents[27–29,32] and 2 were conducted in pregnant women.[26,31] Another 7 studies conducted in general adults were limited by passive smoking assessment accuracy or small sample size, and none of them assessed the influence of husband smoking on hypertension or BP of their wives.[18–20,25,30,33,34] The current study has important public health implications. Despite the fact that, in the past few years, multiple cities in China have launched

smoke-free laws in public spaces, women are still exposed to an alarming amount of tobacco smoke from passive smoking in private homes. Findings from our study highlighted the demand for more restrictions on smoking in private homes where most cigarette smoking and passive smoke exposure take place in women's daily lives. Therefore, clarifying the association between husband smoking and the hypertension of women who are planning for pregnancy is critical to provide evidence on formulating family-based smoking intervention strategies involving both husbands and wives. This type of intervention will be effective for protecting wives from environmental tobacco smoke as well as preventing and reducing hazardous active smoking among husbands. Antismoking public education targeting smoking husbands may also have an impact on reducing harm through changing husbands' knowledge, beliefs, and attitudes about the consequences of smoking on their wives' health.

The current study was the largest study showing an increased risk of wives' hypertension with increasing exposure to husband smoking. Several studies provided inconsistent results on association of risks of having hypertension

Table 6. Association of Husband Smoking With Wife's Hypertension According to Ethnicity*

	Han	Uygur	Zhuang	Hui	Miao	Tujia	Yi	Mongolia	Manchu	Tibetan	Others
Couples smoking status											
Neither-smoker	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Husband-only	1.30 (1.28–1.32)	0.97 (0.84–1.10)	1.27 (1.14–1.41)	1.09 (0.95–1.25)	1.16 (1.00–1.34)	1.29 (1.12–1.49)	1.03 (0.89–1.18)	0.89 (0.75–1.07)	1.31 (1.09–1.56)	0.99 (0.84–1.16)	1.36 (1.27–1.45)
Wife-only	1.46 (1.22–1.75)	2.83 (0.78–10.29)	3.68 (1.06–12.73)	...	2.71 (0.83–8.90)	2.29 (0.68–7.71)	0.91 (0.28–2.91)	2.09 (1.06–4.13)	0.87 (0.21–3.66)	0.86 (0.20–3.62)	1.68 (0.77–3.65)
Mixed	1.48 (1.32–1.66)	0.72 (0.10–5.24)	1.05 (0.25–4.34)	4.69 (2.44–9.00)	0.77 (0.19–3.17)	1.39 (0.59–3.25)	1.21 (0.70–2.10)	0.94 (0.42–2.09)	2.92 (1.59–5.36)	0.68 (0.21–2.21)	1.43 (0.86–2.38)
Spouse smoking amount, cigarettes per day†											
0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1 to 5	1.25 (1.21–1.28)	0.95 (0.78–1.16)	1.17 (0.93–1.48)	1.14 (0.90–1.44)	0.95 (0.66–1.35)	1.05 (0.71–1.55)	0.92 (0.69–1.22)	0.86 (0.59–1.25)	0.89 (0.59–1.36)	1.03 (0.76–1.39)	1.28 (1.11–1.48)
6 to 10	1.26 (1.23–1.29)	1.00 (0.82–1.22)	1.32 (1.15–1.52)	1.10 (0.91–1.33)	1.09 (0.88–1.34)	1.19 (0.98–1.46)	0.96 (0.79–1.16)	0.90 (0.70–1.16)	1.28 (1.00–1.63)	0.99 (0.78–1.27)	1.21 (1.09–1.33)
11 to 15	1.36 (1.30–1.42)	0.67 (0.37–1.22)	1.18 (0.85–1.63)	1.02 (0.63–1.63)	0.92 (0.60–1.40)	1.26 (0.85–1.87)	1.19 (0.87–1.63)	0.97 (0.57–1.65)	1.33 (0.70–2.54)	0.70 (0.41–1.21)	1.17 (0.97–1.40)
16 to 20	1.38 (1.34–1.41)	1.01 (0.72–1.43)	1.18 (1.00–1.40)	1.17 (0.91–1.49)	1.31 (1.06–1.61)	1.38 (1.14–1.67)	1.10 (0.91–1.33)	0.83 (0.63–1.11)	1.51 (1.18–1.94)	1.11 (0.83–1.48)	1.57 (1.43–1.72)
≥21	1.72 (1.59–1.85)	1.19 (0.38–3.75)	2.22 (1.43–3.43)	1.10 (0.44–2.70)	1.94 (1.14–3.31)	1.93 (1.20–3.12)	1.31 (0.74–2.32)	1.10 (0.51–2.40)	2.66 (1.54–4.60)	0.58 (0.23–1.44)	2.04 (1.61–2.59)
$P_{for\ trend}$	<0.0001	0.61	<0.0001	0.47	0.01	<0.0001	0.22	0.43	<0.0001	0.97	<0.0001
Cumulative exposure of husband smoking (pack-marriage years)‡§											
0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0.1 to 2.0	1.23 (1.20–1.26)	0.87 (0.71–1.07)	1.59 (1.33–1.90)	1.19 (0.97–1.45)	1.14 (0.89–1.45)	0.99 (0.71–1.36)	0.86 (0.69–1.08)	0.78 (0.55–1.12)	1.07 (0.76–1.49)	1.36 (1.05–1.75)	1.30 (1.17–1.45)
2.1 to 4.0	1.38 (1.33–1.43)	0.91 (0.68–1.23)	1.35 (1.04–1.75)	0.96 (0.70–1.30)	1.33 (0.97–1.81)	1.49 (1.03–2.14)	0.94 (0.72–1.22)	1.28 (0.90–1.81)	1.17 (0.79–1.72)	0.72 (0.47–1.11)	1.33 (1.15–1.52)
4.1 to 6.0	1.43 (1.37–1.50)	0.70 (0.39–1.14)	1.45 (1.04–2.02)	1.06 (0.71–1.59)	1.56 (1.08–2.25)	1.30 (0.78–2.18)	0.92 (0.65–1.30)	0.84 (0.52–1.36)	1.26 (0.80–1.99)	1.17 (0.72–1.88)	1.27 (1.06–1.52)
6.1 to 8.0	1.55 (1.46–1.65)	0.94 (0.50–1.77)	1.51 (1.00–2.31)	0.77 (0.42–1.42)	1.57 (0.96–2.56)	1.67 (0.96–2.91)	0.85 (0.53–1.36)	0.83 (0.47–1.47)	1.53 (0.94–2.48)	0.54 (0.20–1.48)	1.34 (1.06–1.69)
>8.0	1.64 (1.57–1.71)	1.53 (1.00–2.34)	1.98 (1.46–2.68)	1.07 (0.72–1.59)	1.21 (0.82–1.81)	2.20 (1.61–3.01)	1.46 (1.07–1.98)	0.85 (0.59–1.23)	1.31 (0.97–1.76)	1.27 (0.77–2.08)	1.63 (1.38–1.92)
$P_{for\ trend}$	<0.0001	0.88	<0.0001	0.59	0.01	<0.0001	0.57	0.65	0.02	0.63	<0.0001

*Odds ratios (95% CI) were adjusted for age, urban inhabitants, higher school education, body mass index, and alcohol consumption.
†Couples with female active smoking were excluded from this analysis.
‡Pack-marriage year were used to evaluate the cumulative exposure of spouse smoking, calculated by multiplying the number of packs of cigarettes husband smoked per day by the number of marriage duration.
§Couples with female active smoking and missing marriage duration were excluded from this analysis.

Table 7. Association of Husband Smoking With Wife's Hypertension According to Sodium Intake

Exposure Measurements	Group 1 N (%)	Group 1 OR (95% CI)*	Group 2 N (%)	Group 2 OR (95% CI)*	Group 3 N (%)	Group 3 OR (95% CI)*
Couples smoking status						
Neither-smoker	685 294 (1.82)	1.00	1 649 556 (1.26)	1.00	1 137 298 (2.29)	1.00
Husband-only	285 379 (2.62)	1.35 (1.31–1.39)	581 759 (1.78)	1.33 (1.30–1.36)	509 174 (2.72)	1.17 (1.14–1.19)
Wife-only	1891 (4.44)	1.52 (1.21–1.90)	1251 (3.52)	1.91 (1.40–2.59)	1055 (3.32)	1.21 (0.86–1.70)
Mixed	4471 (3.94)	1.49 (1.27–1.74)	3175 (2.83)	1.52 (1.23–1.89)	3302 (4.00)	1.45 (1.21–1.73)
Husbands' smoking amount†						
0	685 294 (1.82)	1.00	1 649 556 (1.26)	1.00	1 137 298 (2.29)	1.00
1 to 5	69 194 (2.48)	1.43 (1.36–1.51)	145 944 (1.54)	1.23 (1.18–1.29)	117 737 (2.37)	1.07 (1.03–1.11)
6 to 10	125 035 (2.28)	1.24 (1.19–1.29)	255 636 (1.70)	1.32 (1.28–1.37)	218 789 (2.56)	1.13 (1.10–1.16)
11 to 15	23 068 (2.71)	1.43 (1.32–1.55)	44 380 (1.76)	1.35 (1.25–1.45)	44 059 (2.69)	1.17 (1.10–1.24)
16 to 20	63 598 (3.21)	1.39 (1.33–1.46)	127 075 (2.13)	1.40 (1.35–1.46)	119 154 (3.25)	1.28 (1.24–1.33)
≥21	4484 (5.11)	1.91 (1.66–2.19)	8724 (3.23)	1.71 (1.51–1.93)	9435 (4.55)	1.61 (1.46–1.78)
$P_{for\ trend}$	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cumulative exposure of Spouse smoking‡§						
0	747 852 (1.85)	1.00	1 748 583 (1.24)	1.00	1 230 136 (2.27)	1.00
0.1 to 2.0	53 824 (2.63)	1.35 (1.27–1.42)	139 845 (1.71)	1.29 (1.23–1.34)	182 027 (2.35)	1.06 (1.02–1.10)
2.1 to 4.0	22 975 (3.58)	1.52 (1.41–1.63)	51 227 (2.17)	1.34 (1.26–1.42)	67 551 (3.13)	1.23 (1.17–1.29)
4.1 to 6.0	12 833 (4.27)	1.55 (1.42–1.70)	22 891 (2.75)	1.44 (1.33–1.56)	30 864 (3.62)	1.24 (1.16–1.32)
6.1 to 8.0	7380 (4.86)	1.54 (1.38–1.72)	10 653 (3.68)	1.63 (1.47–1.81)	14 287 (4.45)	1.33 (1.23–1.44)
>8.0	15 950 (6.99)	1.58 (1.48–1.70)	17 412 (5.51)	1.74 (1.62–1.87)	20 887 (6.57)	1.52 (1.43–1.61)
$P_{for\ trend}$	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Group 1, Sichuan, Guangdong, Jiangxi, Ningxia, Jilin, Shanghai, Inner Mongolia, Heilongjiang, and Liaoning; Group 2, Jiangsu, Zhejiang, Qinghai, Hubei, Hebei, Shaanxi, Hunan, Fujian, Henan, Guangxi, and Beijing; Group 3, Tianjin, Anhui, Shandong, Hainan, Chongqing, Guizhou, Yunnan, Tibetan, Shanxi, Gansu, and Sinkiang; OR, odds ratio.
*Adjusted for age, urban inhabitants, higher school education, body mass index, and alcohol consumption.
†Couples with female active smoking were excluded from this analysis.
‡Pack-marriage year were used to evaluate the cumulative exposure of Spouse smoking, calculated by multiplying the number of packs of cigarettes husband smoked per day by the number of marriage duration.
§Couples with female active smoking and missing marriage duration were excluded from this analysis.

with exposure to passive smoking, which was not limited to husband smoking. The Ohasama study found that environmental tobacco smoke exposure may increase systolic BP by 4 mm Hg for morning measurement and by 3 mm Hg for evening measurement.[19] Another study identified that second-hand smoke exposure, measured by serum cotinine levels, was associated with increased systolic BP and hypertension, independently. This study also found that the multivariable adjusted OR for hypertension was 1.44 (95% CI: 1.01, 2.04) in the group with serum cotinine levels of 0.218 ng/mL, when compared with those with serum cotinine levels ≤0.025 ng/mL. However, the significant association of passive smoking with hypertension risk was only observed at higher exposure rates other than 1 to 3 times/week in a study conducted in 392 rural Chinese women.[18]

In dose–response analyses, women exposed to a larger husband-smoking amount were at a higher risk of hypertension. It is noteworthy to point out that even the passive exposure of 1 to 5 cigarettes per day would significantly increase women's hypertension risk, indicated by the multivariate-adjusted OR of 1.22 (95% CI: 1.19, 1.25). In the following analysis about the cumulative exposure, a dose–response relationship was also identified. Exposure to husband smoking increased the risk of hypertension through several mechanisms similar to active smoking, including the stimulation of the sympathetic nervous system induced by impaired baroreflex.[17,35] In addition, they were also found to be associated with elevated levels of inflammation markers and impaired endothelia function.[36,37]

Findings of the current study are drawn from a cross-sectional study in over 5 million couples, which ensured the

Table 8. Sensitivity Analyses on Association of Husband's Smoking and Wife's Hypertension*

Exposure Measurements	Sample 1		Sample 2		Sample 3		Sample 4	
	N (%)	OR (95% CI)	N (%)	OR (95% CI)	N (%)	OR (95% CI)	N (%)	OR (95% CI)
Couples smoking status								
Neither-smoker	3 473 168 (1.62)	1.00	1 335 623 (2.31)	1.00	3 458 232 (1.70)	1.00	3 443 854 (1.70)	1.00
Husband-only	1 376 424 (2.11)	1.25 (1.23–1.27)	551 304 (3.09)	1.29 (1.27–1.31)	1 370 226 (2.29)	1.29 (1.27–1.31)	1 365 940 (2.30)	1.29 (1.27–1.31)
Wife-only	4185 (3.46)	1.51 (1.27–1.78)	1754 (4.90)	1.46 (1.17–1.82)	4039 (3.84)	1.51 (1.27–1.78)	4098 (3.88)	1.54 (1.31–1.81)
Mixed	10 897 (2.96)	1.34 (1.20–1.50)	4301 (4.58)	1.47 (1.27–1.70)	10 664 (3.50)	1.50 (1.35–1.67)	10 755 (3.62)	1.51 (1.36–1.67)
Husbands' smoking amount†								
0	3 473 168 (1.62)	1.00	1 335 623 (2.31)	1.00	3 458 232 (1.70)	1.00	3 443 854 (1.70)	1.00
1 to 5	333 303 (1.88)	1.19 (1.16–1.23)	119 292 (2.70)	1.19 (1.14–1.23)	331 230 (2.02)	1.22 (1.19–1.25)	330 100 (2.02)	1.22 (1.19–1.25)
6 to 10	599 551 (1.97)	1.21 (1.18–1.23)	228 662 (2.81)	1.21 (1.18–1.25)	596 922 (2.13)	1.24 (1.22–1.27)	595 040 (2.13)	1.24 (1.22–1.27)
11 to 15	111 531 (2.13)	1.28 (1.23–1.34)	43 670 (3.21)	1.38 (1.31–1.46)	110 980 (2.30)	1.32 (1.27–1.37)	110 713 (2.31)	1.32 (1.27–1.37)
16 to 20	309 497 (2.51)	1.32 (1.29–1.35)	147 041 (3.63)	1.40 (1.36–1.45)	308 584 (2.77)	1.38 (1.34–1.41)	307 627 (2.78)	1.38 (1.35–1.41)
≥21	22 542 (3.56)	1.61 (1.50–1.73)	12 639 (4.93)	1.72 (1.58–1.87)	22 510 (4.14)	1.75 (1.64–1.88)	22 460 (4.14)	1.75 (1.64–1.88)
$P_{for\ trend}$		<0.0001		<0.0001		<0.0001		<0.0001
Cumulative exposure of Spouse smoking‡§								
0	3 727 962 (1.61)	1.00	1 335 623 (2.31)	1.00	3 712 012 (1.69)	1.00	3 698 517 (1.70)	1.00
0.1 to 2.0	375 889 (1.99)	1.19 (1.16–1.22)	255 436 (2.27)	1.14 (1.11–1.17)	374 125 (2.14)	1.23 (1.20–1.26)	373 273 (2.14)	1.23 (1.20–1.26)
2.1 to 4.0	141 783 (2.61)	1.32 (1.28–1.37)	142 067 (2.85)	1.27 (1.23–1.31)	141 299 (2.84)	1.36 (1.32–1.40)	141 036 (2.85)	1.37 (1.32–1.41)
4.1 to 6.0	66 551 (3.09)	1.35 (1.29–1.41)	66 790 (3.45)	1.33 (1.28–1.39)	66 395 (3.43)	1.40 (1.34–1.47)	66 259 (3.44)	1.41 (1.35–1.47)
6.1 to 8.0	32 293 (3.77)	1.43 (1.34–1.51)	32 466 (4.29)	1.44 (1.36–1.52)	32 255 (4.29)	1.51 (1.43–1.60)	32 197 (4.29)	1.51 (1.43–1.60)
>8.0	54 032 (5.49)	1.54 (1.48–1.61)	54 523 (6.36)	1.58 (1.52–1.64)	54 189 (6.33)	1.63 (1.57–1.69)	54 030 (6.34)	1.63 (1.57–1.69)
$P_{for\ trend}$		<0.0001		<0.0001		<0.0001		<0.0001

OR indicates odds ratio; Sample 1, self-reported female hypertension participants are excluded; Sample 2, couples with marriage duration of less than 2 years are excluded; Sample 3, women who did not like vegetables are excluded; sample 4, vegetarian women are excluded.

*ORs were adjusted by age, urban inhabitants, higher school education, body mass index, and alcohol consumption.

†Couples with female active smoking were excluded from this analysis.

‡Pack-marriage year were used to evaluate the cumulative exposure of spouse smoking, calculated by multiplying the number of packs of cigarettes husband smoked per day by the number of marriage duration.

§Couples with female active smoking and missing marriage duration were excluded from this analysis.

statistical power of overall analysis and subgroup analysis. Similar findings and dose–response relationship were also observed in the nation-specific analyses. It is interesting that although women reported no second-hand smoking exposure, those in the husband-only group were also at higher risk of having hypertension. We speculated that third-hand smoking, which accumulates in smoker's fingers, hair, clothes, and rooms and persists for a long time,[38] might also play a role in the development of women' hypertension. The present study differs from other studies, in that the information about wives' exposure to tobacco smoke was obtained by asking the husband participants directly, instead of the wives, improving the accuracy of the exposure measurement. In addition, analysis on the cumulative effect of husband smoking identified that the long-term low-dose exposure of husband smoking was also harmful. Furthermore, subgroup analyses in various ethnicities greatly improved the generalizability of the current findings to the overall population in China.

However, some limitations should be kept in mind when interpreting these study results. First, information on antihypertensive treatment or hypertension duration was not collected in the current study, and BP measurement or the hypertension history was used to define hypertension status. However, those without hypertension history are less likely to take antihypertensive medication, which minimized the likelihood of misclassification bias. Second, husband-smoking exposure was self-reported rather than evaluated by an objective measurement such as serum nicotine levels. Nondifferential misclassification and bias towards null association might have occurred from using our method. In addition, we did not collect information on the brand name of cigarettes, which might influence the results. Third, women might have been exposed to second-hand smoke prior to having husbands who smoked, which was not covered in our questionnaire. However, the association of second-hand smoke with hypertension was more obvious for those with longer marriage duration. This association has minimized the influence of past exposure before marriage. Additionally, results were not substantially changed in sensitivity analysis by exclusion of couples with marriage duration of less than 2 years. Fourth, participants in the current study are couples taking prepregnancy physical examinations and they might be healthier than the general population. This difference may introduce underestimation of the risk in our study population. Fifth, former smokers and current smokers could not be split according to our questionnaire, but former smokers were more likely to be grouped into the reference group, which might also introduce underestimation of the effect. Sixth, provincial analyzed sodium intake was used to account for the potential confounding of sodium intake on association of second-hand smoking with BP, which is not as accurate as

individual sodium intake. In addition, physical activity was not included in the questionnaire, which has limited our ability to address its influence on the association. Finally, a cross-sectional design will introduce recall bias, and cannot draw the temporal association or causal relationship between husband smoking and wives' hypertension, thus warranting prospective studies.

To the best of our knowledge, this study is the first to assess the influence of husband smoking on prevalent hypertension in over 5 million couples. The current study has revealed significant associations between husband smoking and wives' hypertension status in both a categorical and dose–response manner. Considering the great burden of second-hand smoking and hypertension, the current study has several implications for public health. Evidence from the current study fuels the fire for more restrictions on smoke in public venues, as well as at home, and emphasizes the importance of a family-based intervention strategy in tobacco control and hypertension management.

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Disclosures

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