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Association between sleep duration and hypertension of migrant workers in China: a national cross-sectional surveillance study

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ABSTRACT

Objectives To examine the relationship between sleep duration and hypertension of migrant workers aged 18–59 years in China.

Design Population-based cross-sectional study using a complex survey sampling design.

Participants There were 43 655 subjects in our analysis, after excluding people with missing information for key exposure and outcome variables and abnormal values for sleep duration (≤2 or ≥17 hours).

Primary outcome measure Hypertension was defined as systolic blood pressure (BP) ≥140 mm Hg and/or diastolic BP ≥90 mm Hg, or self-reported history of hypertension diagnosis in hospitals at the township (community) level or above and use of hypertensive medicine in the last 2 weeks.

Results Of 43 655 subjects, 15.6% (95% CI 15.1% to 16.1%) of migrant workers had hypertension. The prevalence of hypertension decreased with the increased sleep duration, both in males and females. Logistic regression models, using 7–8 hours sleep/day as the reference, showed a greater odds for hypertension among men and women who reported <6 hours of sleep after adjusting for sociodemographic characteristics, behavioural risk factors, body mass index, diabetes, stroke and myocardial infarction (men: OR 1.26; 95% CI 1.03 to 1.54, women: OR 1.55; 95% CI 1.13 to 2.06, $p_{interaction}$=0.096). Further stratified by age and migration time, it revealed that among adults less than 45 years old, those sleeping 9 or more hours had adjusted odds for hypertension of 0.82 (95% CI 0.72 to 0.93, $p_{interaction}$=0.020),while there was no evidence of an association between sleep duration and hypertension among adults aged 45–59 years. Among adults whose migration time was less than 4.5 years, those sleeping 9 or more hours had adjusted odds for hypertension of 0.80 (95% CI 0.68 to 0.94, $p_{interaction}$=0.097).

Conclusion The association between sleep duration and hypertension varies by age. Short sleep duration (<6 hours) is associated with an increased prevalence of hypertension in both genders.

Strengths and limitations of this study

- Our study addressed an important gap in the literature because no previous study has investigated the association between sleep duration and hypertension among migrant workers in China.
- The statistical analysis considered multistage occupational-stratified clustering sampling method and used proper sample weight, so the results are nationally representative.
- Due to the cross-sectional study design, this study could not determine the causal relationship between sleep duration and hypertension.
- We did not collect data on psychological stress and obstructive sleep apnoea, which may play a role in the relationship between sleep duration and hypertension.

INTRODUCTION

During the past few decades, the population of migrant workers in China continued to grow from 211 million in 2009 to 236 million in 2012, representing more than a sixth of the nation's total population.[1] Changes in living and working conditions as well as lifestyles (eg, physical activity, sleep and diet) caused by active migration are likely to affect the health of migrant workers.[2] However, few studies have examined the relationships between modifiable risk factors and health outcomes in this population.

Epidemiological studies suggest that sleep deprivation and poor quality of sleep are associated with a number of health outcomes, including hypertension.[3–6] According to the 2015 China Sleep Index Report, the average self-reported sleep time among Chinese is 8 hours and 12 min. Studies that examined the relationship between sleep duration and hypertension have shown mixed results.[7–12] For example, Stranges *et al* reported that shorter sleep duration was associated with higher risk of hypertension, which may in turn lead to detrimental cardiovascular effects among women.[8] Nevertheless, Lima-Costa

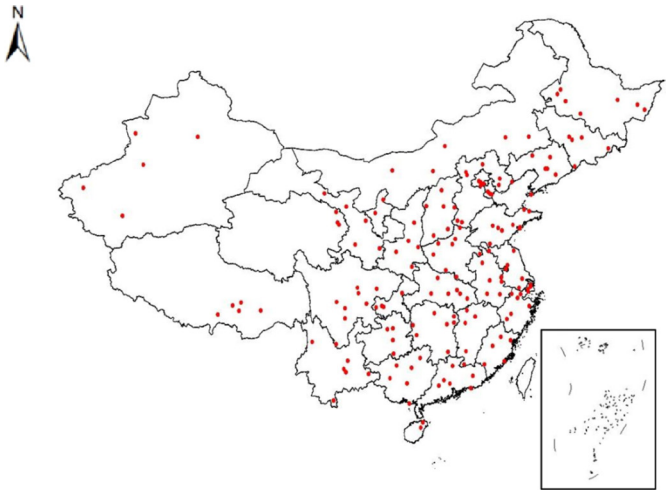

Figure 1 Map of 2012 China Non-communicable and Chronic Disease Risk Factor Surveillance Sites in migrant workers.

et al reported that sleep duration was not associated with hypertension in Brazilian elderly (60–95 years).[10] Although the mechanisms underlying the varying association between sleep duration and hypertension and other cardiovascular outcomes are not fully understood, some studies indicate that the biological pathways may involve overactivity of sympathetic nerve and renin–angiotensin–aldosterone system,[13 14] changes in circadian rhythms,[15] hormone alterations[16] and changes in the immune, metabolic and endocrine systems.[17 18]

The relationship between sleep duration and hypertension in a nationally representative migrant workers in China has not been reported. Therefore, we conducted this study to investigate the association between self-reported sleep duration and the prevalence of hypertension using the data of the 2012 China Non-communicable Disease and Risk Factor Surveillance in migrant workers.

METHODS

Study population

Data were from the 2012 China Non-communicable and Chronic Disease Risk Factor Surveillance of migrant workers from 170 counties in all 31 provinces (including the 4 direct jurisdiction cities and 5 autonomous regions) and the Xinjiang production and construction corps in China. The geographical distribution of surveillance points is presented in figure 1. Migrant workers are defined as those who have lived for more than half a year for work in a town that is different from where the household Hukou (ie, the national household registration in China) was originally registered.[2 19] The participants were 18–59 years old. Students, unemployed persons and visitors were excluded. The 2012 surveillance in migrant workers selected participants by using a multistage clustering sampling method, stratified by occupation. First, within the six major industry categories (ie, manufacturing industry, wholesale and retail trade industry, hospitality and food services industry, social service industry, construction industry and other industries), subindustry categories were selected according to the industry distribution characteristics of the survey area and the industry classification standard of the National Bureau of Statistics; second, within each subindustry category, two or three functional organisations were selected according to its scale using a simple random number allocation method; lastly, 50 available migrant workers from the eligible lists were selected in clusters from departments within each functional organisation until the predetermined sample size 51 000 (300 participants in each county and there were 170 counties) according to the national report on migrant workers and the ratio between the resident population and the migrant workers was reached.[2 20]

Overall, there were 50 209 subjects participated in the 2012 surveillance. After preliminary data cleaning (we excluded the participants whose questionnaire had logical error), the effective sample size was 48 704 nationally. Of the 48 704 subjects, 5049 subjects were excluded from the statistical analysis because of missing or abnormal values in key exposure and outcome variables including self-reported sleep time, self-reported hypertension and objectively measured systolic blood pressure (SBP) and diastolic blood pressure (DBP). Abnormal values referred to migrant workers whose self-reported sleep time was ≤2 hours or ≥17 hours. The final analytical sample included 43 655 participants.

Sleep duration

Sleep duration was assessed by a self-reported questionnaire with the following question: 'How many hours do you usually sleep a day (including at night and naps) in the past 30 days?' Consistent with existing research,[10–12] sleep duration was categorised into five categories: <6 hours, 6(ie, ≥6 and <7 hours), 7 (ie, ≥7 and <8 hours), 8 (ie, ≥8 and <9 hours), ≥9 hours.

Definition of hypertension

Blood pressure was measured with an electronic sphygmomanometer (Omron HBP 1300) after the subjects had rested for 5 min in sitting position. SBP and DBP were measured three times with a 1 min interval. Three readings of SBP and DBP were recorded, and the average of the last two readings was used for data analysis. Hypertension was defined as SBP ≥140 or DBP ≥90 mm Hg, or based on self-reported diagnosis of hypertension in hospitals at the township (community) level hospitals or above and had been taking medicine in the last 2 weeks.

Covariates

Information on sociodemographic characteristics (sex, age, education, income, inflow area, etc), behavioural risk factors for chronic diseases (smoking, alcohol consumption, physical activity, etc) and body mass index (BMI), diabetes, stroke and myocardial infarction were collected through a questionnaire by face-to-face interview with

trained interviewers. As the effects of sleep duration on hypertension varied with age and duration of migration time, study participants were divided into two age groups: 18–44 and 45–59 years.[20] Duration of migration time was categorised into two groups using a median split: <4.5 and ≥4.5 years. China's Southern and Northern divisions are defined by the Huaihe River in the Qinling Mountains. Beijing, Tianjin, Hebei, Henan, Shanxi, Shaanxi, Shandong, Liaoning, Jilin, Heilongjiang, Qinghai, Gansu, Ningxia, Inner Mongolia and Xinjiang belong to the northern region. Shanghai, Chongqing, Jiangsu, Anhui, Hubei, Hunan, Guangdong, Guangxi, Zhejiang, Fujian, Jiangxi, Sichuan, Guizhou, Yunnan, Tibet and Hainan belong to the Southern region. According to the Guidelines for Prevention and Control of Overweight and Obesity in Adults in China,[21] BMI was calculated by the clinically measured height and weight and was divided into three groups: underweight (BMI <18.5 kg/m^2), normal weight (18.5 ≤BMI <24 kg/m^2), overweight and obesity (BMI ≥24 kg/m^2). According to the Dietary Guidelines for Chinese Residents,[22] excessive drinking was defined as an average daily alcohol intake of at least 25 g for males and 15 g for females. According to WHO recommendation, insufficient intake of vegetables and fruits was defined as an average daily intake of vegetables and fruits combined of less than 400 g.[23] According to the World Cancer Research Foundation standards, the cumulative intake of pork, beef and mutton ≥100 g/day was defined as excessive red meat intake.[24] Participants with diabetes were defined as individuals who had fasting blood glucose ≥7.0 mmol/L and/or blood glucose ≥11.1 mmol/L in the oral glucose tolerance test-2 hours and/or have been diagnosed as diabetes by township (community) level hospitals or above. Stroke and myocardial infarction patients were defined as individuals who had been diagnosed by township (community) level hospitals or above.[20]

Statistical analysis

Due to the deviation of some important indicators (mainly age, sex and occupation) between the sample and the overall distribution caused by the sampling method, in order to make the results of the survey representative of migrant workers aged 18–59 in China, the results used the data of the dynamic monitoring of migrant workers in 2012 by the former National Population and Family Planning Commission as the basis for a postweighted adjustment. The Taylor series variance method was used to estimate the 95% CI of sampling error and rate; Rao-Scott χ^2 tests were conducted to test for group differences in prevalence or percentage, and the logistic regression models were used to examine the trends for ordered categorical variables. Multivariable logistic regression models were employed to calculate the OR and 95% CI for the likelihood of hypertension associated with shorter or longer duration of sleep comparing to the reference category of 7 hours stratified by age, sex and migration time, which were performed post hoc. Heterogeneity of OR by sex, age and migration time were tested post hoc by adding to the model an interaction term with sleep duration. Model 1 was an unadjusted model. Model 2 was adjusted for sociodemographic characteristics (such as sex, age, migration time, marriage status, education level, occupation, annual income, inflow area, migration time, working hours) and behavioural risk factors for chronic diseases (such as total static behaviour time, smoking status, alcohol consumption, vegetable and fruit intake, red meat intake and BMI). On the basis of model 2, model 3 was adjusted for diabetes, stroke and myocardial infarction because these were comorbidity in hypertension and were important confounders. Complex survey design weights was applied to all statistical description and inferences to get nationally representative estimates. All statistical analyses were carried out using SAS V.9.4 (SAS Institute). All statistical tests were two tailed, and significance was defined as p<0.05.

Patients and public involvement

There was no patient involvement in this study.

RESULTS

A total of 43 655 valid samples were included in the analysis. The sleep duration of migrant workers was mainly concentrated in 8–9 and 7–8 hours, accounting for 45.9% and 24.5%, respectively. The characteristics of the study population for subgroups according to sleep duration were presented at table 1. The proportion of subjects who slept for less than 6 hours was higher among those aged 45 or older when compared with younger subjects. With increased migration time and working time, the proportion of subjects with less than 6 hours of sleep increased, while the proportion of subjects with 9 or more hours of sleep decreased. With the increase of BMI and alcohol consumption, the proportion of subjects who slept for more than 9 hours decreased. There was no statistical difference in the intakes of vegetable and fruit and red meat across different groups of sleep duration.

In 2012, 15.6% of migrant workers aged 18–59 years had hypertension (20.4% in men and 9.0% in women) (table 2). The prevalence of hypertension in both men and women increased with age. The prevalence of hypertension in migrant workers decreased with increased education level. Among different occupations, the highest prevalence of hypertension was observed in the construction industry (21.6%). The prevalence of hypertension in the north was higher than that in the South (18.7% in the North and 12.7% in the South). The prevalence of hypertension in both males and females increased with increased migration time. Higher prevalence of hypertension was also associated with overweight/obesity, smoking and excessive drinking in both males and females. These trends were consistent with those observed for SBP, DBP and pulse pressure (online supplementary tables S1–S3). Specifically, the prevalence of hypertension in overweight/obese migrant workers (44.7%) was nearly

Table 1 Different demographic characteristics of migrant workers in China across categories of sleep duration

Characteristics	Sleep duration (hour)					
	<6 n=1520 (2.7)	6 n=4589 (9.5)	7 n=10 660 (24.5)	8 n=19 525 (45.9)	≥9 n=7361 (17.4)	P value
Sex						
Male	847 (2.9)	2819 (10.9)	6231 (26.2)	10548 (44.3)	3762 (15.7)	<0.0001
Female	673 (2.4)	1770 (7.5)	4429 (22.3)	8977 (48.0)	3599 (19.8)	
Age (years)						
18–44	804 (2.3)	2932 (8.8)	7907 (24.2)	15467 (46.6)	6049 (18.1)	<0.0001
45–59	716 (6.1)	1657 (15.1)	2753 (27.5)	4058 (39.2)	1312 (12.1)	
Marital status						
Unmarried	161 (1.7)	684 (7.3)	2081 (22.4)	4530 (47.1)	2123 (21.5)	<0.0001
Married/cohabitating	1289 (2.9)	3748 (10.1)	8353 (25.2)	14631 (45.6)	5106 (16.2)	
Widowed/divorced/separated	70 (6.3)	157 (14.3)	226 (24.2)	364 (39.9)	132 (15.3)	
Educational level						
Illiterate or primary school	433 (4.6)	906 (11.4)	1524 (21.2)	2928 (42.4)	1381 (20.4)	0.0236
Junior high school	609 (3.0)	1763 (9.4)	4040 (23.5)	7732 (46.2)	3011 (17.9)	
Senior high school	311 (2.2)	1172 (9.6)	2763 (25.0)	5009 (46.2)	1786 (17.0)	
College graduate or above	167 (1.7)	748 (8.4)	2333 (28.1)	3856 (46.9)	1183 (14.9)	
Industry sector						
Manufacturing	225 (2.3)	796 (9.1)	1934 (25.1)	3324 (45.6)	1209 (17.9)	0.0368
Wholesale and retail trade	257 (2.7)	723 (9.5)	1723 (24.4)	3240 (46.7)	1142 (16.7)	
Accommodation and catering	216 (2.7)	706 (9.0)	1844 (25.2)	3296 (45.2)	1353 (17.9)	
Services	271 (3.1)	794 (10.2)	1757 (24.4)	3251 (45.8)	1190 (16.5)	
Construction	278 (3.5)	757 (10.2)	1718 (24.5)	3300 (45.3)	1276 (16.5)	
Other	272 (2.9)	806 (9.9)	1669 (23.6)	3087 (45.9)	1178 (17.7)	
Annual household income (RMB, in quartiles)						
<20000	475 (2.9)	1296 (9.3)	2722 (22.1)	5257 (45.7)	2294 (20.0)	<0.0001
20 000~	359 (2.7)	1000 (8.6)	2543 (24.4)	4801 (46.4)	1811 (17.9)	
26 000~	180 (2.5)	611 (9.2)	1454 (25.3)	2638 (45.6)	999 (17.4)	
≥36000	506 (2.7)	1682 (10.4)	3941 (26.0)	6829 (45.7)	2257 (15.2)	
Inflow area						
South	819 (2.8)	2338 (9.5)	5383 (24.1)	9996 (45.5)	3930 (18.1)	0.0097
North	696 (2.6)	2231 (9.5)	5250 (25.4)	9364 (45.9)	3348 (16.6)	
Migration time (year)						
<2	335 (2.4)	888 (8.0)	2251 (22.3)	4745 (47.3)	2059 (20.0)	<0.0001
2~	326 (2.5)	1082 (8.4)	2751 (23.5)	5403 (47.6)	2039 (18.0)	
4.5~	341 (2.4)	1092 (9.6)	2553 (24.8)	4604 (46.0)	1666 (17.2)	
≥10	518 (3.5)	1527 (12.0)	3105 (27.4)	4773 (42.5)	1597 (14.6)	
Working hours (hour)						
<8	116 (3.0)	311 (9.2)	754 (26.1)	1193 (42.2)	564 (19.5)	<0.0001
8~	787 (2.3)	2610 (8.8)	6474 (23.7)	12565 (47.6)	4583 (17.6)	
≥10	617 (3.5)	1668 (11.1)	3432 (25.8)	5767 (43.0)	2214 (16.6)	
Total static behaviour time (hours)						
<4	803 (3.2)	2220 (10.3)	4995 (25.2)	8756 (44.6)	3292 (16.7)	<0.0001
≥4	717 (2.3)	2369 (8.9)	5665 (24.0)	10769 (46.8)	4069 (18.0)	
BMI						

Continued

Table 1 Continued

Characteristics	Sleep duration (hour) <6 n=1520 (2.7)	6 n=4589 (9.5)	7 n=10 660 (24.5)	8 n=19 525 (45.9)	≥9 n=7361 (17.4)	P value
< 18.5	1020 (2.6)	2907 (8.9)	6918 (23.7)	13299 (45.8)	5418 (19.0)	<0.0001
18.5–23.9	439 (2.9)	1432 (10.4)	3193 (26.0)	5413 (46.3)	1711 (14.4)	
≥24	61 (2.6)	250 (12.6)	549 (28.5)	813 (43.8)	232 (12.5)	
Smoking status						
Non-current smoker	985 (2.4)	2843 (8.4)	7123 (23.9)	13594 (47.2)	5142 (18.1)	<0.0001
Current smoker	535 (3.3)	1746 (11.8)	3537 (25.8)	5931 (43.1)	2219 (16.0)	
Alcohol consumption in the past 12 months						
Never drinking	761 (2.5)	2102 (8.3)	5018 (22.5)	10259 (48.4)	3785 (18.3)	<0.0001
Drinking but not excessive	525 (2.5)	1849 (10.0)	4500 (26.5)	7492 (44.1)	2912 (16.9)	
Excessive drinking	234 (4.8)	638 (13.7)	1142 (25.7)	1774 (40.9)	664 (14.9)	
Vegetable and fruit intake						
Insufficient intake	642 (2.6)	2026 (9.6)	4783 (25.0)	8678 (45.7)	3162 (17.1)	0.1539
Adequate intake	878 (2.8)	2563 (9.4)	5874 (24.2)	10845 (46.0)	4199 (17.6)	
Red meat intake						
Normal intake	680 (2.8)	2011 (9.6)	4492 (24.4)	8077 (45.6)	3111 (17.6)	0.9821
Excessive intake	840 (2.6)	2578 (9.4)	6168 (24.7)	11448 (46.0)	4250 (17.3)	
Hypertensive patients						
Yes	429 (3.9)	1115 (11.77)	2066 (26.04)	3505 (44.44)	1117 (13.85)	<0.0001
No	1091 (2.49)	3474 (9.10)	8594 (24.26)	16020 (46.09)	6244 (18.06)	
Participants with diabetes						
Yes	53 (4.7)	130 (15.5)	208 (23.2)	344 (42.4)	99 (14.2)	<0.0001
No	1467 (2.7)	4459 (9.4)	10452 (24.6)	19181 (45.9)	7262 (17.4)	
Stroke patients						
Yes	13 (9.9)	13 (13.7)	22 (24.6)	32 (40.1)	12 (11.7)	0.0144
No	1506 (2.7)	4569 (9.5)	10623 (24.6)	19465 (45.8)	7336 (17.4)	
Myocardial infarction patients						
Yes	8 (14.8)	7 (9.5)	11 (19.1)	20 (44.8)	13 (11.8)	0.0006
No	1511 (2.7)	4575 (9.5)	10634 (24.6)	19477 (45.8)	7335 (17.4)	

Data are expressed as n (%). The percentages in table are row percent and were calculated with complex survey design weights. Rao-Scott χ^2 tests were conducted to test for differences in percentage for unordered categorical variables and logistic regression models were used to examine the trends for ordered categorical variables.
BMI, body mass index.

twice as high as that in normal weight migrant workers (20.8%). The prevalence of hypertension in excessive drinkers (29.3%) was 2.3 times that in those who had never consumed alcohol (12.7%).

Among migrant workers aged 18–59 years in China, the prevalence of hypertension decreased with increased sleep duration, both in males and females. Similar trends were also observed for SBP and DBP (online supplementary figures S1 and S2). The highest prevalence of hypertension was observed among those with less than 6 hours of sleep duration (26.4% for men and 16.0% for women), while the lowest prevalence was observed among those reporting more than 9 hours of sleep (17.3% for men and 7.1% for women) (figure 2). Figure 3 and online supplementary table S4 present adjusted ORs for the likelihood of having hypertension among subgroups defined by sex, age and migrant time across the five categories of sleep duration using 7–8 hours of sleep as the reference. Compared with the reference group, men and women who slept <6 hours a day had higher odds for hypertension (men: OR 1.27; 95% CI 1.04 to 1.56, women: OR 1.59; 95% CI 1.19 to 2.14), while those who slept ≥9 hours a day had lower odds for hypertension in model 2 (men: OR 0.85; 95% CI 0.75 to 0.96, women: OR 0.82; 95% CI 0.67 to 0.99). This trend persisted after additionally adjusting for diabetes, stroke and myocardial infarction in model 3.

Table 2 Prevalence of hypertension among migrant workers in China

Characteristics	Male			Female			Total		
	No of hypertension	Prevalence (%, 95% CI)	P value	No of hypertension	Prevalence (%, 95% CI)	P value	No of hypertension	Prevalence (%, 95% CI)	P value
Age (years)									
18–44	3000	17.3 (16.5 to 18.1)	<0.0001	1241	7.6 (7.06 to 8.1)	<0.0001	4241	13.0 (12.5 to 13.5)	<0.0001
45–59	2635	39.9 (38.3 to 41.4)		1356	28.3 (26.6 to 30.0)		3991	36.8 (35.6 to 38.0)	
Marital status									
Unmarried	466	8.6 (7.6 to 9.6)	<0.0001	90	2.3 (1.67 to 3.0)	<0.0001	556	6.1 (5.5 to 6.8)	<0.0001
Married/cohabitating	5050	24.3 (23.4 to 25.2)		2423	10.8 (10.1 to 11.4)		7473	18.4 (17.9 to 19.0)	
Widowed/divorced/ separated	119	21.1 (16.9 to 25.3)		84	11.2 (7.7 to 14.7)		203	16.4 (13.6 to 19.3)	
Educational level									
Illiterate or primary school	827	21.6 (19.9 to 23.3)	0.0074	897	15.3 (13.9 to 16.7)	<0.0001	1724	18.4 (17.3 to 19.6)	<0.0001
Junior high school	2282	21.1 (20.1 to 22.2)		969	9.3 (8.5 to 10.1)		3251	16.2 (15.5 to 16.9)	
Senior high school	1548	20.5 (19.2 to 21.8)		492	7.5 (6.5 to 8.5)		2040	15.4 (14.5 to 16.2)	
College graduate or above	978	18.5 (17.1 to 19.8)		239	5.1 (4.2 to 5.9)		1217	12.8 (11.9 to 13.7)	
Industry sector									
Manufacturing	1013	19.6 (18.0 to 21.2)	0.0177	374	8.1 (7.0 to 9.1)	0.0050	1387	14.4 (13.4 to 15.4)	<0.0001
Wholesale and retail trade	754	20.9 (19.2 to 22.6)		595	9.4 (8.4 to 10.5)		1349	15.3 (14.3 to 16.3)	
Accommodation and catering	645	18.3 (16.7 to 19.9)		448	8.8 (7.7 to 10.0)		1093	13.6 (12.6 to 14.6)	
Services	774	20.4 (18.7 to 22.1)		449	8.9 (7.9 to 10.0)		1223	14.7 (13.7 to 15.7)	
Construction	1316	22.9 (21.5 to 24.3)		321	13.2 (11.5 to 14.9)		1637	21.6 (20.3 to 22.9)	
Other	1126	21.1 (19.5 to 22.6)		405	9.7 (8.4 to 11.1)		1531	16.9 (15.8 to 18.0)	
Annual household income (RMB, in quartiles)									
< 20000	949	19.6 (18.1 to 21.1)	0.0465	1237	10.2 (9.4 to 11.1)	0.0006	2186	13.6 (12.8 to 14.4)	<0.0001
20 000~	1166	20.8 (19.3 to 22.2)		680	8.7 (7.8 to 9.5)		1846	14.5 (13.60 to 15.3)	
26 000~	685	18.7 (17.1 to 20.3)		272	7.6 (6.4 to 8.8)		957	14.0 (12.9 to 15.1)	
≥36 000	2835	21.1 (20.1 to 22.1)		408	8.0 (6.9 to 9.1)		3243	18.3 (17.5 to 19.2)	
Inflow area									
South	2379	16.8 (15.8 to 17.7)	<0.0001	1162	7.4 (6.8 to 8.1)	<0.0001	3541	12.7 (12.1 to 13.3)	<0.0001
North	3233	24.4 (23.3 to 25.6)		1397	10.6 (9.7 to 11.5)		4630	18.7 (17.9 to 19.5)	
Migration time (year)									
<2	1073	15.8 (14.6 to 17.0)	<0.0001	484	7.4 (6.4 to 8.4)	<0.0001	1557	12.2 (11.4 to 13.0)	<0.0001
2~	1297	18.9 (17.6 to 20.1)		656	8.4 (7.5 to 9.3)		1953	14.1 (13.3 to 14.9)	
4.5~	1258	20.1 (18.8 to 21.0)		868	8.6 (7.6 to 9.6)		1847	15.1 (14.2 to 16.0)	

Continued

Table 2 Continued

Characteristics	Male			Female			Total		
	No of hypertension	Prevalence (%, 95% CI)	P value	No of hypertension	Prevalence (%, 95% CI)	P value	No of hypertension	Prevalence (%, 95% CI)	P value
≥10	2007	26.2 (24.8 to 27.5)		2597	11.8 (10.7 to 12.9)		2875	20.7 (19.8 to 21.7)	
Working hours (hour)									
<8	358	24.6 (21.7 to 27.5)	0.0110	268	10.3 (8.5 to 12.2)	0.4672	626	17.1 (15.3 to 18.8)	0.2464
8~	3448	20.5 (19.6 to 21.4)		1550	8.8 (8.2 to 9.4)		4998	15.5 (14.9 to 16.1)	
≥10	1829	19.7 (18.5 to 20.8)		779	9.0 (8.1 to 9.9)		2608	15.4 (14.6 to 16.2)	
Total static behaviour time (hour)									
<4	2664	20.1 (19.1 to 21.0)	0.2332	1242	10.21 (9.4 to 11.0)	<0.0001	3906	16.10 (15.4 to 16.8)	0.0244
≥4	2971	20.8 (19.8 to 21.7)		1355	8.10 (7.5 to 8.7)		4326	15.14 (14.5 to 15.8)	
BMI (kg/m^2)									
<18.5	2648	16.0 (15.2 to 16.7)	<0.0001	1711	7.00 (6.50 to 7.50)	<0.0001	4359	11.4 (10.9 to 11.8)	<0.0001
18.5–23.9	2180	22.5 (21.3 to 23.6)		786	16.29 (14.8 to 17.8)		2966	20.8 (19.9 to 21.8)	
≥24	807	45.4 (42.6 to 48.2)		100	37.63 (29.4 to 45.9)		907	44.7 (42.0 to 47.3)	
Smoking status									
Non-current smoker	2980	19.5 (18.6 to 20.4)	0.0003	2554	8.6 (5.2 to 12.0)	0.8346	5209	13.79 (13.3 to 14.3)	<0.0001
Current smoker	2655	21.7 (20.7 to 22.7)		43	9.0 (8.5 to 9.5)		3023	19.20 (18.3 to 20.1)	
Alcohol consumption in the past 12 months									
Never drinking	1553	18.6 (17.5 to 19.7)	<0.0001	2167	9.8 (9.2 to 10.4)	<0.0001	3720	12.7 (12.2 to 13.3)	<0.0001
Drinking but not excessive	2681	18.5 (17.6 to 19.4)		381	6.3 (5.4 to 7.1)		3062	15.6 (14.8 to 16.3)	
Excessive drinking	1401	30.4 (28.7 to 32.1)		49	12.2 (7.7 to 16.8)		1450	29.3 (27.7 to 31.0)	
Vegetable and fruit intake									
Insufficient intake	2609	20.3 (19.2 to 21.3)	0.5626	1120	9.8 (9.0 to 10.7)	0.0043	3729	16.1 (15.4 to 16.8)	0.0198
Adequate intake	3025	20.6 (19.7 to 21.5)		1476	8.4 (7.7 to 9.0)		4501	15.1 (14.5 to 15.7)	
Red meat intake									
Normal intake	2232	22.5 (21.3 to 23.7)	<0.0001	1362	9.4 (8.6 to 10.2)	0.0997	3594	15.9 (15.2 to 16.7)	0.1773
Excessive intake	3403	19.3 (18.4 to 20.1)		1235	8.6 (7.9 to 9.2)		4638	15.3 (14.7 to 15.9)	
Participants with diabetes									
Yes	248	45.7 (40.5 to 51.0)	<0.0001	146	41.6 (32.8 to 50.3)	<0.0001	394	44.6 (40.1 to 49.1)	<0.0001
No	5387	20.0 (19.3 to 20.7)		2451	8.7 (8.2 to 9.2)		7838	15.2 (14.7 to 15.6)	
Stroke patients									
Yes	57	54.9 (38.1 to 71.7)	<0.0001	35	25.7 (5.8 to 45.6)	0.0116	92	46.9 (32.6 to 61.1)	<0.0001
No	24111	20.4 (19.7 to 21.1)		19388	8.9(8.4 to 9.5)		43499	15.5 (15.0 to 16.0)	

Continued

Table 2 Continued

Characteristics	Male			Female			Total		
	No of hypertension	Prevalence (%, 95% CI)	P value	No of hypertension	Prevalence (%, 95% CI)	P value	No of hypertension	Prevalence (%, 95% CI)	P value
Myocardial infarction patients									
Yes	33	48.9 (27.3 to 70.5)	0.0014	26	21.9 (2.1 to 41.8)	0.0636	59	39.6 (22.6 to 56.5)	0.0002
No	24135	20.4 (19.7 to 21.1)		19397	9.0 (8.4 to 9.5)		43532	15.5 (15.1 to 16.0)	
Total	5635	20.4 (19.7 to 21.2)	–	2597	9.0 (8.5 to 9.5)	–	8232	15.6 (15.1 to 16.1)	–

The values outside the columns are all prevalence and the values inside the columns are 95% CI. All prevalences were weighted with complex survey design weights; the 95% CIs take into account the complex sampling design. Rao-Scott χ^2 tests were conducted to test for differences in prevalence for unordered categorical variables and logistic regression models were used to examine the trends for ordered categorical variables.

BMI, body mass index.

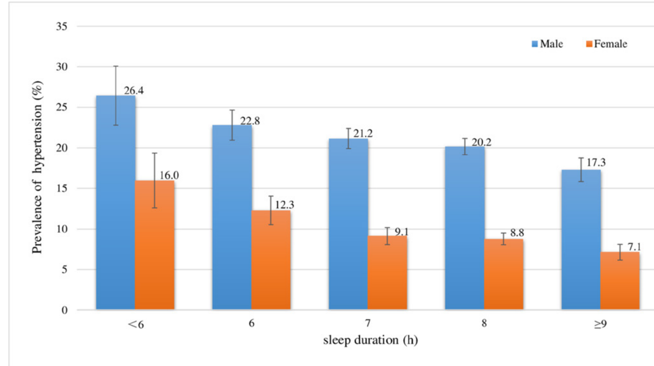

Figure 2 Prevalence (95% CI) of hypertension classified by sleep duration in different sex groups.

Among young adults aged 18–44 years, subjects who slept ≥9 hours a day compared with those sleeping 7–8 hours had lower odds of hypertension in model 2 and model 3 (model 2: OR 0.82; 95% CI 0.71 to 0.92, model 3: OR 0.82 95% CI 0.72 to 0.93). However, in the older adults aged ≥45 years, no significant association was found between sleep duration and hypertension in either model 2 or model 3. Among migrant workers whose migrant time <4.5 years, subjects who slept ≥9 hours a day compared with those sleeping 7–8 hours had lower odds of hypertension in model 2 and model 3 (model 2: OR 0.75; 95% CI 0.64 to 0.88, model 3: OR 0.80; 95% CI 0.68 to 0.94). Subjects with migrant time ≥4.5 years who slept <6 hours a day compared with those sleeping 7–8 hours had greater odds of hypertension in model 2 and model 3 (model 2: OR 1.41; 95% CI 1.14 to 1.76, model 3: OR 1.29; 95% CI 1.01 to 1.61).

DISCUSSION

This study found that 2.7% of migrant workers in China slept for less than 6 hours, 17.4% slept for 9 hours or more per day. Migrant workers who slept for less than 6 hours had higher odds for hypertension, while those who slept for more than 9 hours had lower odds for hypertension. There were also differences in the relationship between sleep duration and hypertension among participants with different gender, age and migration time. The odd for hypertension was 1.26-fold (95% CI 1.03 to 1.54) higher in men with short sleep duration (<6 hours) than in those with a normal sleep duration (7–8 hours) after adjusting for multiple confounders. Among women, less than 6 hours of sleep was associated with 55% increase in the odds of hypertension, compared with 26% increase in men, which suggested that the effects of short sleep on hypertension might be stronger among women than among men ($p_{interaction}$=0.096), and is consistent with several previous studies. For example, in a cross-sectional study of rural population in China, a sample of 1033 men and 783 women showed that hypertension was associated with short sleep duration in women.[25] Results from the Whitehall II Cohort Study showed that compared with

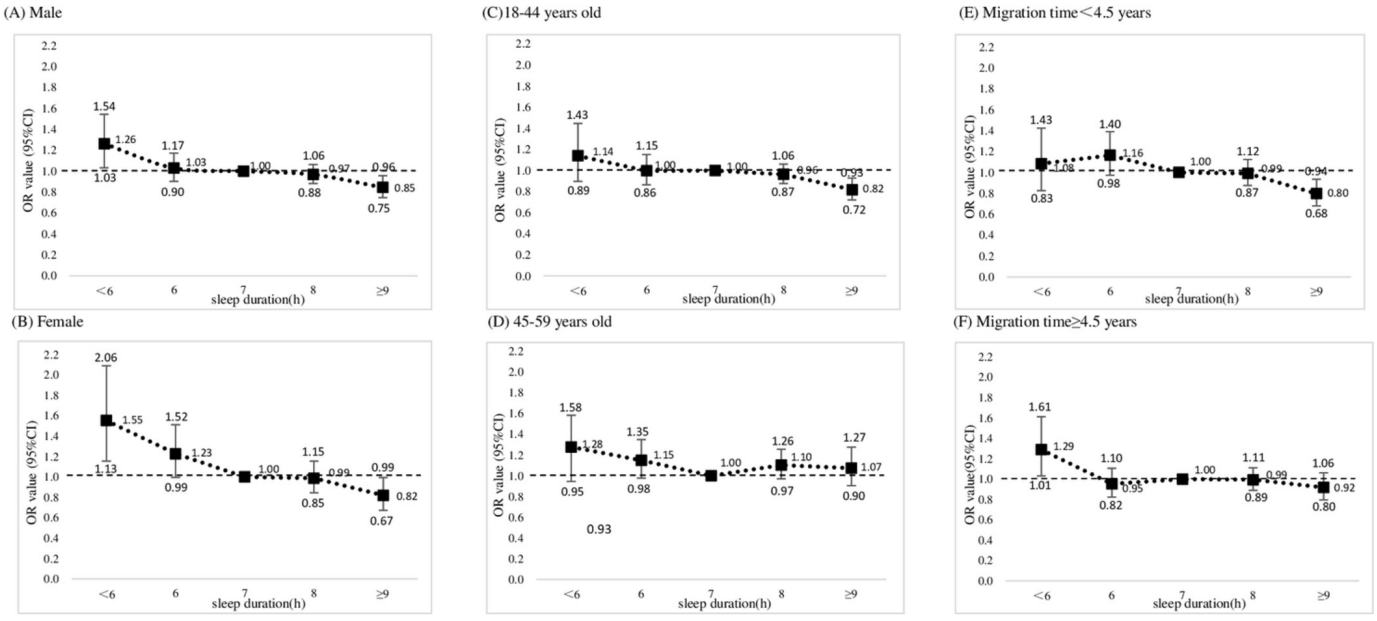

Figure 3 Association between sleep duration and hypertension in different subgroups. ORs in each group are presented as squares with 95% CIs represented by extended lines. The horizontal reference line represents an OR value of '1'. The dashed line represents the effects of different sleep durations on hypertension. (A) The male subgroup. (B) The female subgroup. (C) The 18–44 years old subgroup. (D) The 44–59 years old subgroup. (E) The subgroup with migration time <4.5 years. (F) The subgroup with migration time ≥4.5 years. Multivariable logistic model adjusted sex, age, migration time, marital status, education level, annual income, inflow area, working time, static behaviour time, red meat intake, smoking status, alcohol consumption, vegetable and fruit intake, BMI, diabetes, stroke and myocardial infarction. BMI, body mass index.

7 hours of sleep, short duration of sleep (5 hours per night) was associated with a higher risk of hypertension among women with an inverse linear trend across decreasing hours of sleep while no association was detected in men.[26] In a cross-sectional survey conducted among patients with hypertension in the hypertensive outpatient clinic of Anzhen Hospital and a community hospital in Beijing, China, researchers showed a modest association between short sleep duration and uncontrolled hypertension in middle-aged women but not in men.[27] There may be two possible reasons that may explain the sex difference in the correlation between sleep duration and hypertension. The first reason is biological differences between women and men, including differences in genes and sex hormone levels. In particular, among perimenopausal and menopausal women, hormones fluctuate significantly, which may interact with sleep to influence blood pressure and lead to a stronger relationship between hypertension and short sleep duration in women than in men.[25] Second, men and women have different family roles, educational levels, social pressures and accesses to healthcare. Stress has an important impact on cortisol level[28] and some studies have shown that when compared with men, women have a higher level of cortisol in the morning,[29] which may affect the relationship between sleep duration and high blood pressure.

Among migrant workers aged 18–44 years, subjects with sleep duration more than 9 hours had lower odds for hypertension compared with those whose sleep duration was 7–8 hours ($p_{interaction}$=0.020), while there was no correlation between sleep duration and hypertension in those aged 45–59 years (p>0.05). This finding was also consistent with those from previous studies.[7 30] The pathogenesis of hypertension is different between younger and older adults. Hypertension in the middle aged and elderly is usually due to age-related arterial stiffness and increased peripheral resistance, while hypertension in the younger population is mainly caused by increased sympathetic activity and cardiac output.[31] Sleep is related to sympathetic activity and cardiac output,[32] which may partially explain the differences in the relationship between sleep duration and hypertension between the two age groups. Studies have shown that shorter sleep duration at night increases the risk of hypertension.[33] Compared with young people, middle-aged people have shorter sleep hours at night and have the habit of napping during the day, which may weaken the relationship between cumulative sleep duration and hypertension. Previous studies have found a significant association between daytime napping and hypertension and longer afternoon nap was associated with a higher increased risk of hypertension,[34 35] and Kallistratos *et al* found that midday sleep significantly decreased average day SBP/DBP in hypertensive people.[36] The relationship and mechanisms between daytime napping and hypertension are not clearly demarcated and unfortunately, our study did not distinguish between daytime napping and nighttime sleep. Therefore, we were not able to evaluate

the specific effect of daytime napping on hypertension definitely. In addition, the prevalence of chronic diseases such as hypertension, diabetes and obesity in middle-aged people is usually higher than that of young people, and chronic diseases increase the total mortality rate of middle-aged people.[37] Thus, survival bias may be another reason that sleep duration is unrelated to hypertension in middle-aged people.

With the increase of migration time, the prevalence of hypertension in migrant workers also increases, which may be related to the diminished healthy immigration effect.[38] The health status of migrants is selectively better than other residents and general population in the emigration area[39] and the health advantages of immigrants disappear with increased years of residency.[40 41] In our study, with the increase of migration time, the proportion of migrants who slept for less than 6 hours increased and the relationship between less than 6 hours of sleep and increased hypertension was stronger among people with a longer migration time ($p_{interaction}$=0.097). Our findings might reflect a cohort effect in which migrant workers with a longer migration time have a slightly stronger association between sleep duration and hypertension. Studies in migrant population have shown that health outcomes varied by length of migration time.[42–44] However, the effect of different migration time on the association between sleep duration and hypertension has been rarely studied. Different environmental changes, living habits, acculturative stresses and illness burden faced by migrant workers with different migration time may explain these differences.[45]

Inconsistent with the 'U' pattern in other studies,[12 46 47] an inverse relation between sleep duration and hypertension was observed in our study, which was similar with the relationship between BMI and sleep duration.[48 49] The inverse relation in our study may be due to the pressure on social integration, the types of jobs that migrant workers engage in and the public health services they enjoy, which are quite different from those of the permanent residents.[50] Moreover, there were no hypothetical mechanisms for long sleep duration causing disease or death investigated either in the current paper or in other laboratory or epidemiological studies.[51]

No study has examined the relationship between sleep duration and hypertension in migrant workers in China. Few Asian studies have reported on the relationship between sleep duration and hypertension. A Korean national cross-sectional study showed that short sleep duration (≤5 hours) was independently associated with hypertension in young and middle-aged Korean adults but there was no association in those aged ≥65 years.[52] A cross-sectional analysis of the CARRS Study in Delhi, Chennai and Karachi in South Asia showed that there was no association between either short or long duration of sleep with hypertension after adjusting for other hypertension risk factors.[53] A study conducted in Japanese male workers showed that sleep duration of 6 hours or more did not relate to the occurrence of any components of the metabolic syndrome, including hypertension.[54] Different study results in Asia suggested that there was considerable variation in the relationship between duration of sleep and hypertension by gender, age groups and geographical regions. In this study, we analysed the relationship between sleep duration and hypertension in migrant workers of different gender, age groups as well as migration time, and adjusted various possible confounding factors. Therefore, it is of great significance to reflect the correlation between sleep duration and hypertension in China's migrant workers. It also provided some support for the previous research on biological mechanism and clues for further basic research.

This study has several limitations. First, data on psychological stress, obstructive sleep apnoea and sleep quality were not collected in this surveillance, while they may affect the association between sleep duration and hypertension. Studies found that obstructive sleep apnoea was an independent risk factor for hypertension and the risk for hypertension was synergistically increased in patients with both obstructive sleep apnoea and short sleep duration.[55 56] The Penn State Cohort study found that chronic insomnia with short sleep duration was associated with an increased risk for incident hypertension and may be a premorbid modifiable risk factor for hypertension.[57] These findings indicate that obstructive sleep apnoea and insomnia (especially in combination with short sleep) are confounders in the association between sleep duration and hypertension. However, due to lack of data on obstructive sleep apnoea and sleep quality, it is impossible to determine the impact of obstructive sleep apnoea and insomnia on the sleep duration of migrant workers. Second, our surveillance collected self-reported sleep duration, which is subjective to recall errors. Finally, this study is a cross-sectional study, so we could not determine the causal relationship between sleep duration and hypertension. We encourage future prospective studies to better evaluate a potential causal relationship between sleep duration and hypertension.

CONCLUSION

The results from this study suggest that the Chinese migrant workers who slept less than 6 hours had a higher prevalence of hypertension in both genders. However, the association was not found in the middle-aged population aged 45–59 years. Further research is needed to investigate the biologic mechanisms that link sleep duration and hypertension and to explore the efficacy of sleep interventions for the treatment and prevention of hypertension in migrant workers.

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