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Prevalence of Hypertension in Employees of Oil and Gas Companies: A Sex-Stratified Analysis from Northwest China

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Abstract

Background: This study aims to determine whether employees of an oil and gas company in Shaanxi, China, are associated with a higher prevalence of hypertension compared to the general population's age and geographical region.

Methods: Cross-sectional study is used. Participants with hypertension who fulfilled at least one of the criteria: (1) systolic blood pressure ≥140 mm Hg; (2) diastolic blood pressure ≥90 mm Hg; (3) self-reported use of antihypertensive medication in the past two weeks; or (4) self-reported history of hypertension.

Result: Compared to the general population, the employees were young, with a higher proportion of men having a higher body mass index and were more likely to be alcoholics and smokers. Before propensity score matching, the prevalence of hypertension was slightly lower in the employees compared to that of the general population. After matching, overall, the employees were more likely to have hypertension compared to the general population. Gender-based subgroup analysis showed that male employees had a higher prevalence of hypertension, while the female employees had a lower prevalence of hypertension compared to the general population.

Conclusion: The research results show that compared with the general population, male oilfield employees are more prone to hypertension. This finding potentially has implications for the subsequent designating of preventative modalities. Specifically, policies concerning the prevention, treatment, and control of hypertension, as well as health management in the oil and gas companies should be formulated differently for male and female workers and be more focused on males and front-line workers.

Keywords: Hypertension; Prevalence; Oil and Gas companies; Employees; China;

List of Abbreviations

HRFS: Health Risk Factors Survey

PSM: Propensity Score Matching

NHSS: National Health Service Survey

NHFPC: National Health and Family Planning Commission

BMI: Body Mass Index

ASDM: Absolute Standardized Difference in Mean

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Introduction

Globally, hypertension has become a major health challenge due to its high prevalence and considerable risk for cardiovascular disease, premature death, and disability [1-3]. Since 2000, the prevalence of hypertension has been increasing in developing countries, including China, making prevention and control of hypertension imperative [4-6]. Accordingly, more efforts are needed to determine the factors associated with hypertension risk. This is particularly important for employees aged 18–60, who have become a predominant population in the developing countries[7].

For employees in oil and gas industries, unhealthy lifestyles and occupational exposure to various industrial pollutions have been recognized as the main risk factors for the pathogenesis of chronic diseases, including hypertension.8 Employees in petrochemical industries are regularly engaged in long-time work shifts (12 hours) and night shift, and even departure from their families, all of which could lead to unhealthy lifestyle, including high calorific intake, fatty diets with poor fiber, lack of physical activity, poor sleep quality, and high mental stress [8-9]. These unhealthy factors could lead to a higher risk of cardiovascular diseases and even adversely affect productivity [10-12]. Employees in oil and gas industries are more likely to be exposed to gas flaring, oil-polluted surfaces, and underground water than the general population [13-14]. Evidence suggests that chronic and prolonged exposure to these contaminants also increases the risks of cardiovascular diseases, including hypertension [15-18].

Most oil and gas companies in China are large state-owned enterprises. Compared to the private sector labor force, employees in state-owned companies have unique advantages in coping with the damage caused by chronic diseases. For example, they often have access to a better health care system jointly established by companies and the government. It could provide free periodic physical examinations, supplemented health management services, and an almost free treatment plan [19]. In addition, the income of employees in oil and gas companies is at a high level, which enables them to better cope with the potential risk factors for their health.

The study aimed to compare the prevalence of hypertension among employees of the oil and gas industries. Their age and geographical regions were compared with the general population, considering the adverse influence of poor lifestyles and the benefits of better health care systems and high-level incomes. Furthermore, some studies have suggested potential gender-difference underlying the potential influences of a few risk factors on the risk of hypertension [20-22]. This may also be the case for the employees of the oil and gas companies. For example, female employees are more likely to work in offices, and the influence of occupational exposure may be less significant. Therefore, it is also interesting to evaluate whether there is a gender difference regarding the prevalence of hypertension in the employees compared to the general population.

In this study, using the data of the Health Risk Factors Survey for employees of Changqing Oil Field Company (one of the largest oil and gas companies in China) and the residents aged 18-60 in Shaanxi Province, we aimed to compare the prevalence of hypertension between these two populations. The Propensity Score Matching (PSM) method [23] was applied to minimize the potential influences of covariate distributions between study groups. Besides, we also explored whether there was a gender difference underlying the prevalence of hypertension in the employees compared to the general population.

Methods

Health Risk Factors Survey in Changqing Oil Field Filiale [24]

Health examinations for employees of Changqing Oil Field have been conducted annually since 2007. In 2013, a Health Risk Factors Survey (HRFS) was performed in addition to the annual health examination. The Fourth Military Medical University developed the survey questionnaire, which consisted of 11 sections and more than 30 questions, including demographic factors, physical characteristics, personal disease history, family disease history, smoking, diet, physical activity, sleep, mental condition, and living environment. A face-to-face interview was conducted for the survey, with administrative support from the health management department of the company. The interviewers were recruited from health administrators at all company levels and were trained before the survey was implemented. All the 25 secondary units of the company participated in the survey, and 52,000 questionnaires were distributed. In total, 50,013 valid questionnaires were obtained. The validity of the survey questionnaires was checked by health administrators before data entry.

National Health Service Survey (NHSS) in Shaanxi Province, China

In Shaanxi's 2013 NHSS, a representative sample including 32 districts/counties, 160 sub-districts/townships, 320 residential committees/villages, and 20,702 households were randomly selected using a 3-stage cluster random sampling method. A total of 57,529 participants participated in the interview. Instructions for performing face-to-face interviews on NHSS questions were provided by the National Health and Family Planning Commission (NHFPC) of China. The interviewers were recruited from the local healthcare workers and trained by supervisors from the local healthcare branches of the NHFPC. Shaanxi adopted the NHSS form with the same questionnaire and survey and quality control methods and surveyed simultaneously as the national survey. For participants who could answer the questions in writing, personal filling out the forms by following the instructions was

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preferable. For the participants who could not write, face-to-face interviews with a trained interviewer were indicated. The questionnaire used for the NHSS in 2013 included more than 200 questions regarding diseases, hospitalizations, health-related behaviors, socioeconomic factors, vaccinations, disease control, and health services specific to women and children.

Participants of the HRFS survey and NHSS

The employees in Changqing Oil Field were adult, in-service individuals, most aged between 19 to 60 years. However, the participants of the NHSS covered a wider age range. In order to improve comparability, only 19–60-year-old participants were selected for this study. The analysis was conducted using samples containing 49,698 Changqing employees and 34,820 residents from Shaanxi province (after excluding cases with missing values in key analysis variables).

Definition of hypertension and related risk factors

For the employees of Changqing, participants with hypertension were considered if they fulfilled at least of the criteria: (1) systolic blood pressure ≥140 mm Hg; (2) diastolic blood pressure ≥90 mm Hg; (3) self-reported use of antihypertensive medication in the past two weeks; or (4) self-reported history of hypertension. For the residents of Shaanxi, hypertension was self-reported, and the interviewers approved and validated the diagnosis by medical organizations.

Definition of health risk factors

The sociodemographic factors selected from the two surveys in this study included gender, age, body mass index (BMI), height, and weight. Age was divided into three categories: 19–30, 31–45, and 46–60 years. BMI was also divided into three categories, including normal or underweight (<24 Kg/M2), overweight (24–28 Kg/M2), and obese (>28 Kg/M2). Other risk factors included smoking status (no smoking, smoking cessation, and smoking) and alcohol drinking (drinking more than once a week and no drinking).

Statistical analysis

The propensity score was calculated by the logistic regression model, in which Changqing employees were taken as the treatment group, and the residents of Shaanxi Province were taken as the control group. Before PSM, z-tests were used for comparing continuous variables, and the Chi-Square tests were used for comparing the categorical variables. P<0.05 values were statistically significant. Several potential risk factors for hypertension were also evaluated with the logistic regression analysis, including gender, alcohol drinking, and smoking as categorical variables and age and BMI as continuous variables. The nearest neighbor matching method was used with a matching ratio of 1:1 and a caliper value of 0.038. This resulted in 26,178 matched cases. The absolute standardized difference in mean (ASDM) was used to evaluate the matching results. A confounding factor was considered to be balanced between the treatment and control group when ASDM was smaller than 0.1 [25]. After PSM, both the univariate and multivariate logistic models were used to evaluate whether the employees were associated with a higher prevalence of hypertension as compared to the matched general residents. Variables with P<0.1 in the balance tests were included as covariates in the multivariate analyses. The PSM was conducted using the SPSS's plug-in "psmatching 3.02". The statistics were performed with the SPSS 24 and R 3.2.5.

Results

The characteristics of the samples before PSM

The characteristics of the samples before PSM are shown in Table 1. Compared to the general population, the employees were younger, with higher proportions of males, but more likely to be associated with risk factors including obesity, smoking, and alcohol drinking (Pall<0.01).

Table 1: Main characteristics of the participants before propensity score matching.

Variables	Employees	General population	*P* Value
Male (n, %)	31,176 (62.7)	17,289 (49.7)	<0.01
Age (Mean ± SD)	36.3±8.8	42.3±11.3	<0.01
Age group			
19-30 (n, %)	15,119 (30.4)	6,934 (19.9)	<0.01
31-45 (n, %)	26,389 (53.1)	12,613 (36.2)	
46-60 (n, %)	8,190 (16.5)	15,273 (43.9)	
Height (Mean ± SD)	168.7±13.2	165.4±9.5	<0.01
Weight (Mean ± SD)	66.5±7.6	61.1±7.0	<0.01
BMI (Mean ± SD)	23.3±3.8	22.3±2.9	<0.01
Normal or underweight (n, %)	31,402 (63.2)	26,181（75.2）	<0.01
Overweight (n, %)	14,425 (29.0)	7,471（21.5）	
Obese (n, %)	3,871 (7.8)	1,168（3.4）	
Drinking more than once a week (n, %)	15,560 (32.4)	7,000（23.1）	<0.01
Smoking (n, %)*			
Non-smoking	32,399 (65.2)	23,332（67.0）	<0.01
Smoking cessation	1,476 (3.0)	703（2.0）	
Smoking	15,823 (31.8)	10,785（31.0）	

BMI, body mass index; SD, standard deviation

The prevalence of hypertension before PSM

The prevalence of hypertension in the overall sample and different subgroups before PSM is shown in Table 2. The overall prevalence of hypertension was slightly lower in the employees compared to that of the general population (5.8% vs. 7.6%, P<0.01). Stratified analyses showed that the prevalence of hypertension was lower in the employees than in the general population in some subgroups (female, non-drinking, non-smoking, and those in any BMI stratum) but higher in other subgroups (Pall<0.01).

Table 2: Prevalence of hypertension in each subgroup of the employee and the general population before propensity score matching (N*, %).

Subgroups	Employees	General population	*P* Value
Gender			
Male	2,449 (7.9)	1,154 (6.7)	<0.01
Female	456 (2.5)	1,482 (8.5)	<0.01
Age			
19-30 years	184 (1.2)	15 (0.2)	<0.01
31-45 years	1,369 (5.2)	428 (3.4)	<0.01
46-60 years	1,352 (16.5)	2,193 (14.4)	<0.01
BMI			
Normal or underweight	845 (2.7)	1,372 (5.2)	<0.01
Overweight	1,456 (10.0)	1,004 (13.4)	<0.01
Obese	604 (16.2)	260 (22.3)	<0.01
Drinking			
Drinking	1,574 (10.1)	440 (6.3)	<0.01
Non-drinking	1,331 (3.9)	2,196 (7.9)	<0.01
Smoking			
Non-smoking	1,124 (3.5)	1,835 (7.9)	<0.01
Smoking cessation	277 (18.8)	97 (13.8)	<0.01
Smoking	1,504 (9.5)	704 (6.5)	<0.01
Overall	2,905 (5.8)	2,636 (7.6)	<0.01

*N was the number of subjects who were with hypertension.

BMI, body mass index;

Balance of covariates after PSM

After PSM, the distributions of the baseline factors between the employees and the general population are shown in Table 3. Most of the baseline factors were balanced between the two groups (P>0.1) except for weight, BMI (both continuous and categorical variables), and age (both continuous and categorical variables). As shown in Table 4, the ASDMs of most covariate variables were >0.1 before PSM, except for smoking status. After PSM, all of the ASDMs of most covariate variables were <0.1, suggesting adequate balances of these factors between groups.

Table 3: Baseline characteristics of the participants after propensity score matching.

Variables	Employees	General population	*P* value
Male (n,%)	14,026(53.6)	13,959(53.3)	0.56
Height (cm)	166.6(7.4)	166.5(6.8)	0.14
Weight (Kg)	62.8(10.9)	62.5(9.9)	**0.01**
BMI (kg/m²)	22.5(3.3)	22.5(3.0)	0.08
Normal or underweight underweight underweight underweight	2,017(7.7)	1,777(6.8)	**<0.01**
Overweight	16,791(64.1)	17,207(65.7)	
Obesity	7,370(28.2)	7,194(27.5)	
Age （year）	39.0(9.0)	38.8(10.6)	**0.02**
19-30	5,268(20.1)	6,933(26.5)	**<0.01**
31-45	14,459(55.2)	11,725(44.8)	
46-60	6,451(24.6)	7,520(28.7)	
Drinking	6,228(23.8)	6,254(23.9)	0.79
Smoking			
No smoking	17,678(67.5)	17,612(67.3)	0.77
Smoking cessation	601(2.3)	618(2.4)	
Smoking	7,899(30.2)	7,948(30.4)	

BMI, body mass index; SD, standard deviation
Height , Weight , BMI, Age (Mean, SD).

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Table 4: The ASDMs of the covariates before and after propensity score matching.

	Before PSM	After PSM
Propensity Score	0.82	0.02
Male	-0.26	-0.01
Weight	-0.57	-0.02
Height	-0.47	-0.01
BMI	-0.33	-0.01
Age	-0.53	-0.01
Drinking more than once a week	-0.28	<0.01
Smoking		
Smoking cession	-0.07	0.01
Smoking	-0.02	<0.01

ASDM, the absolute standardized difference in mean; PSM, propensity score matching; BMI, body mass index;

The prevalence of hypertension after PSM

As shown in Table 5, the prevalence of hypertension between the employees and the general population was not statistically significant after PSM (6.2% vs. 5.8%, P=0.09). However, a higher prevalence of hypertension was observed in male employees as compared to general male participants (9.0% vs. 6.2%, P<0.01), but a lower prevalence was observed in female employees as compared to the female general participants (2.9% vs. 5.4%, P<0.01). Further subgroup analyses showed a higher prevalence of hypertension in employees than in the general population in participants with older age (31–45 and 46–60 years), larger BMI (Overweight and Obesity), and unhealthy lifestyle (drinking, smoking, and smoking cessation), but a lower prevalence of hypertension in employees than in the general population in participants with younger age (19–30 years), smaller BMI (normal or underweight), and healthier lifestyle (no drinking and no smoking groups).

Results of logistic regression analysis after PSM are shown in Table 6. The unadjusted analysis suggested that overall, employees were associated with a higher hypertension prevalence than the general population (OR=1.20, 95% CI=1.11–1.29, P=0.03). Consistent results were shown in the multivariate-adjusted model, including age and BMI 1.1 (95% CI: 1.02-1.19, P=0.01). Besides, advanced age and larger BMI were also associated with hypertension in the overall population.

Furthermore, results of logistic analyses stratified by gender in Table 6 showed that male employees were associated with a higher prevalence of hypertension than the general male participants (unadjusted model: OR=1.51, 95% CI=1.38-1.65, P<0.01; adjusted model: OR=1.43, 95% CI=1.31-1.58, P<0.01), while the female employees were associated with a lower prevalence of hypertension as compared to the female general participants (unadjusted model: OR=0.52, 95% CI=0.46-0.59, P<0.01; adjusted model: OR=0.64, 95%CI=0.56-0.73, P<0.01). Advanced age and larger BMI were also associated with hypertension in both males and females.

Table 5: The prevalence of hypertension in each subgroup after propensity score matching (N*, %).

Factors	Employees	General population	*P* Value
Overall	1,612 (6.2)	1,520 (5.8)	0.09
Gender			
Male	1,261 (9.0)	859 (6.2)	<0.01
Female	351 (2.9)	661 (5.4)	<0.01
Age (years)			
19-30	617 (3.3)	637 (3.4)	0.04
31-45	781 (12.4)	692 (11.2)	0.68
46-60	214 (20.0)	191 (19.2)	0.71
BMI(kg/m^2)			
Normal or underweight	42 (0.8)	15 (0.2)	<0.01
Overweight	603 (4.2)	406 (3.5)	<0.01
Obesity	967 (15.0)	1,099 (14.6)	0.53
Drinking			
More than once a week	707 (11.4)	390 (6.2)	<0.01
No drinking	905 (4.5)	1,130 (5.7)	<0.01
Smoking			
No smoking	668 (3.8)	961 (5.5)	<0.01
Smoking cessation	112 (18.6)	85 (13.8)	0.02
Smoking	832 (10.5)	474 (6.0)	<0.01

*N was the number of subjects with hypertension.
BMI, body mass index;

Discussion

Employees of oil and gas companies are likely to have poor lifestyles but sound healthcare systems and payment, which may affect the employees' vulnerability to hypertension. Results of this large cross-sectional study indicate that the prevalence of hypertension for Changqing's employees is different according to gender than the general population. Male employees have a higher prevalence, but females have a lower prevalence than the age-matched general population. These results may underline the potential difference in the vital pathogenetic factors of hypertension between male and female employees of oil and gas companies, which are essential for the subsequent designating of preventative modalities.

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Table 6: Factors associated with the prevalence of hypertension in the participants.

	Unadjusted Model*			Adjusted Model**		
	OR	95% CI	*P* value	OR	95% CI	*P* value
Overall Participants						
Group						
General population	1			1		
Employees	**1.2**	**1.11-1.29**	**0.03**	**1.1**	**1.02-1.19**	**0.01**
BMI(kg/m^2)						
Normal or underweight	-	-	-	1		
Overweight	-	-	-	2.91	2.69-3.16	<0.01
Obesity	-	-	-	5.66	4.98-6.44	<0.01
Age(year)						
18-30	-	-	-	1		
31-45	-	-	-	7.35	5.62-9.61	<0.01
46-60	-	-	-	28.49	21.85-37.15	<0.01
Male Participants						
Group						
General population	1			1		
Employees	**1.51**	**1.38-1.65**	**<0.01**	**1.43**	**1.31-1.58**	**<0.01**
BMI(kg/m^2)						
Normal or underweight	-	-	-			
Overweight	-	-	-	2.48	2.25-2.74	<0.01
Obesity	-	-	-	4.72	4.03-5.52	<0.01
Age(year)						
18-30	-	-	-			
31-45	-	-	-	7.62	5.48-10.59	<0.01
46-60	-	-	-	26.15	18.90-36.18	<0.01
Female Participants						
Group						
General population	**1**			**1**		
Employees	**0.52**	**0.46-0.59**	**<0.01**	**0.64**	**0.56-0.73**	**<0.01**
BMI(kg/m^2)						
Normal or underweight	-	-	-	1		
Overweight	-	-	-	3.15	2.73-3.63	**<0.01**
Obesity	-	-	-	6.54	5.21-8.20	**<0.01**
Age(year)						
18-30	-	-	-	1		
31-45	-	-	-	8.07	5.07-12.82	**<0.01**
46-60	-	-	-	33.08	20.87-52.42	**<0.01**

*: The covariate of the logistic model included the variable of interest.
**: The covariate of the logistic model included the source of the participants, BMI, and age.
BMI, body mass index, OR, odds ratio; CI, confidence interval.

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In this study, we found that employees in Changqing Oil Field were younger but had multiple poor lifestyle factors than the general residents, including obesity, smoking, and alcohol drinking. Moreover, the proportion of males was also higher for the employees. As evidenced by the previous studies, age, male sex, and poor lifestyle are strongly associated with hypertension [21]. As a result, comparing the prevalence of hypertension without adjusting for these confounding factors may bias the results. Based on the direct comparison of the prevalence of hypertension between the two groups, the direction of the difference between the two groups was inconsistent. For example, for the Changqing Oil Field employees, the prevalence of hypertension was much lower in those female strata aged 19–30, non-drinkers, and non-smokers. The imbalance of the covariates between the two populations highlights the necessity for using an appropriate strategy to minimize the influence of confounding factors, such as using PSM.

After using the PSM, the results for both the unadjusted and adjusted (by BMI, age, and gender) models showed that Changqing employees were more vulnerable to hypertension than Shaanxi residents. One possible reason is that employees in oil and gas enterprises are more likely to be exposed to occupational hazards such as physical (dust, high temperature and pressure, noise, and power frequency electromagnetic fields) and chemical factors (including H2S, aromatic hydrocarbons, alkanes, etc.) [8-9]. Hypertension can be aggravated by defective protective facilities or weak self-protection consciousness among employees. Another reason may be related to the fact that Changqing employees' workplaces are primarily located in remote areas, far from the city. Transportation costs are high, and the commute is time-consuming, which may reduce the use of available medical and health services. Finally, many oil and gas enterprises implement a 24-hour shift system for front-line jobs, which may cause shift work sleep disorder (SWD) characterized by biological rhythm disorders, such as changes in dietary behavior, insomnia, etc., thereby increasing the risk of hypertension [10].

Another exciting finding after PSM is the potential gender difference regarding the prevalence of hypertension in the employees compared to the general population. Specifically, male employees have a higher prevalence. However, females have a lower prevalence than the age-matched general population. This could be explained via the following reasons. First, in oil and gas industry, most male employees primarily engage in technical operational roles. Their work intensity is greater, and their working environment is worse than that of the females. This contrasts with female employees, mostly in support roles. In general, the working and living conditions of the females were relatively better[26]. Second, female workers in Changqing Oil Field are, by definition, paid employees, while most of the female residents in Shaanxi Province live in the countryside, where women are mostly unemployed and receive less health knowledge[27]. As a result, they may be less willing and unable to purchase medical services than the women working in the Changqing Oil Field.

Strengths and limitations of this study

An essential strength of this study is that the data sources are from two large-scale, high-quality surveys. Within the surveys, the data of Shaanxi residents was derived from Shaanxi's 2013 NHSS, which was a large-scale provincial representative survey. The participants of the Changqing survey accounted for about 60% of all staff and covered all types of employees. Therefore, the two samples well represent their respective populations. Another strength of this study is that the two populations were in the same region. Therefore, apart from occupational characteristics, the environmental factors of participants from the two groups are similar, minimizing the influence of other factors. Furthermore, we used the PSM method to balance the distribution of age, gender, BMI, smoking, and drinking within the two groups. This further minimized the potential influences of these confounding factors.

Despite the above strengths, this study also has limitations. First, the Changqing employees were not randomly selected, which may lead to selection bias. However, it could be inferred that potential biases have been effectively reduced after correcting for the main confounding factors of hypertension using PSM and the logistic model. In addition, although several confounding factors (such as age, gender, BMI, smoking, and alcohol consumption) have been adjusted, some unobserved confounding factors may not be fully adjusted. Finally, the study's cross-sectional design precludes the demonstration of a causal relationship between the vulnerability of hypertension and the characteristic of the employees.

Conclusion

In conclusion, this large cross-sectional study showed that the prevalence of hypertension for Changqing's employees is different according to gender compared to the general population. Male employees have a higher prevalence, but females have a lower prevalence than the age-matched general population. These findings may be significant for the subsequent designating of preventative modalities, considering the potential gender difference. Regarding policies concerning the prevention, treatment, and control of hypertension, health management in the company should formulate different policies for male and female workers and be intensely focused on males and front-line workers.

Availability of data and materials

The data supporting this study's findings are available from Administrative Affairs Centre, Changqing Oil Field Filiale, Xi'an, Shaanxi Province, China. However, restrictions

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apply to the availability of these data, which were used under license for the current study, and are not publicly available. Data are, however, available from the authors upon reasonable request and with permission of Administrative Affairs Centre, Changqing Oil Field Filiale, Xi'an, Shaanxi Province, China.

Conflict of Interest Statement

The authors declare that they have no competing interests.

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Ethics Declarations

Ethics approval and consent to participate

The HRFS was approved by the Department of Health Management of the Changqing Oil Field Filiale. The NHSS obtained ethical approval (license number: 2013 (65)) from the institutional review board of the Chinese National Bureau of Statistics. Both surveys have pledged to protect respondents' privacy and facilitate the anonymous analysis of the data. For these reasons, written consent was not required. The informed consent statement was printed on the questionnaire to ask for the interviewees' permission.

Consent for publication

Not applicable.

Author Contributions

Zhijun Tan led the research and funding acquisition. All authors contributed equally including data collection, analysis and writing for this manuscript. All authors read and approved the final manuscript.

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Declaration of generative AI in scientific writing

The authors did not use generative artificial intelligence (AI) and AI-assisted technologies in the writing process.

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