ORIGINAL ARTICLE

WILEY

A cross-sectional study of the interaction between night shift frequency and age on hypertension prevalence among female nurses

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Abstract

Night shift is a common work schedule. This study aimed to analyze the interaction between age and frequency of night shift on the hypertension prevalence. A census questionnaire was conducted in 512 medical institutions in 11 cities of Hebei Province. One lakh twenty-one thousand nine hundred three female nurses were included in this study. Binary Logistic regression analysis was done by SPSS Version 26.0. The youngest age group without night shift was used as the reference group. The odds ratio was calculated by different combinations of interaction items. Interaction

coefficients were calculated by an Excel table designed by Andersson. Compared with the 18–25 year old ones without night shift, there existed an additive interaction between the age of 36–45 and more than 5–10 night shifts per month on hypertension prevalence. Odds ratio, the relative excess risk of interaction, the attributable proportion of interaction, and the synergy index and their 95% confidence intervals were 2.923(2.292-3.727), 0.631(0.309-0.954), 0.216(0.109-0.323), 1.488(1.158-1.913). Additive interaction was also found between the age of 36–45 and more than 10 night shifts per month. OR, RERI, API, SI, and their 95% confidence intervals were 3.430(2.273-5.175) 1.037(0.061-2.013), 0.303(0.089-0.516), and 1.746(1.093-2.788). There also existed an additive interaction between the age of 46–65 and more than 5–10 night shifts per month on hypertension prevalence. OR, RERI, API, SI, and their 95% confidence intervals were 7.398(5.595-9.781) 1.809(0.880-2.739), 0.245(0.148-0.341), and 1.394(1.199-1.622).There existed interaction between specific age groups and night shift frequency on the prevalence of hypertension among female nurses.

KEYWORDS
hypertension—women, night shift work, nurses

1 | INTRODUCTION

With the rapid development of the social economy, the living and working environment, as well as the working mode of human beings, have undergone tremendous changes. Currently, the night shift schedule is becoming more and more common in various careers, which may cause individual biological rhythm disorders and increase their risk of disease.[1] Nursing is an important part in medical and health service. Only by rotating the night shifts could nurses provide continuous nursing service for patients and meet their need for rehabilitation. In addition, the number of female staff in the nursing profession is dominant.[2-4] Previous studies suggested that they tended to have a higher risk of cardiovascular disease than men when engaged in night shifts.[5] Ferguson and associates[6] performed a cohort study of 2151 workers for incident hypertension, finding that recent night shift work may be associated with higher rates of hypertension. However, a systematic review and meta-analysis conducted by Manohar and associates[7] found there was no significant association between night shift status and risk of hypertension. In addition, age was also a risk factor of hypertension. This study hypothesized that the additive interaction between specific age and specific night shift frequency had an impact on the prevalence of hypertension. At present, the interaction between age and night work is not clear. Understanding the interaction between night work and age of female nurses was of great significance to take targeted measures against the prevalence of hypertension in this population. Therefore, the interaction impact exerted by night shift work and age on hypertension was controversial and worthy of adequate attention.

The purpose of this paper is to describe and report the interaction between night shift frequency and age in the pathogenesis of hypertension, so that we can provide scientific evidence for female nurses of different age groups on reasonably planning frequency of night shift work and decrease the risk of hypertension.

2 | METHODS

2.1 | Study population

In this study, female nurses of 512 medical institutions in 11 cities of Hebei Province were involved.

2.2 | Selection and exclusion criteria

The inclusion criteria of participants were as follows.

1. Registered incumbents that had been engaged in nursing work for at least 1 year;

2. At least 18 years old;

3. Informed consent was administered.

Exclusion criteria: Those who took sick leave, maternity leave, or went out for further study.

2.3 | Procedures

This study was composed of two parts: questionnaire survey and blood pressure measurement. The blood pressure measurement was done by nurses themselves. For they are medical workers with professional competence. Figures of these two parts were uploaded via online survey (SO JUMP) to the Hebei Nursing Quality Control Center (NQCC).

A professional research group was established. The items of the questionnaire were selected studying related literature. The definitions of survey items in the questionnaire were clearly presented, and detailed notes of questionnaire filling were attached with documents. For example, night shift referred to shifts that started after 19:00 and ended before 09:00 in the next morning.[8] For body mass index (BMI), BMI <18.5 kg/m^2 was lean; 18.5–23.9 kg/m^2 was normal; 24.0–27.9 kg/m^2 was overweight; $\geq$28.0 kg/m^2 was obese.[9] A presurvey was performed to optimize the questionnaire. The notice of the investigation was issued by provincial level NQCC to municipal NQCCs of 11 cities in Hebei Province. Then, the municipal level NQCCS further sent the notice to local medical institutions. The head of nursing department and head nurse were supposed to supervise nurses to complete the questionnaire. During the period of data collection, the inclusion and exclusion criteria were strictly implemented to ensure the homogeneity of the participants. The survey was conducted in batches by region, with data collected and checked daily by two members of research group. The daily reports were fed back to the municipal NQCC. If there existed a missing value or an abnormal value, corresponding questionnaire would be sent back for further inquiry. After the completion of all data collection, the data was checked again for completeness and logical rationality by two members.

2.4 | Content of the survey

The questionnaire was completed by participants. Its contents were as follows: Blood pressure figures; The average monthly night shift frequency in the past half-year (The data was got by the question: "What was the average number of night shifts per month of you in the past half a year?". The answer included "No night shift/less than or equal to five night shifts/ more than five to ten night shifts/ and more than ten night shifts.")Factors related to the workload:grade of the hospital (Primary hospital/Secondary hospital/Tertiary hospital), department (Internal medicine/Surgery/Gynecology/Pediatrics/Emergency/Operation room/Intensive care unit/ Clinic/ ENT/Administration/Medical technology/Others). Social demographic information: age(18-25; 26-35, 36-45, 46-65), height, weight, location of the hospital (Shijiazhuang/ Baoding/ Cangzhou/ Chengde/Handan/Hengshui/ Langfang/ Qinhuangdao/Tangshan/Xingtai/Zhangjiakou, educational background (Specialist qualification/Bachelor degree/Graduate), marital status (Married/ Unmarried/Divorced or widowed). Medical history (Whether taking hypertensive medicine (Yes/No), the years of hypertension medical history,history of high blood pressure (Yes/No), hyperlipidemia (Yes/No), diabetes (Yes/No), history of taking antihypertensive medications (Yes/No), family history of hypertension (Yes/No), menstruation status (Regular/ Irregular/Menopausal), maternal history (times of pregnancies, deliveries, miscarriages), history of taking oral contraceptives, history of pregnancy-induced hypertension (No/Yes/No history of labor), history of hormone replacement therapy (Yes/No). Living habits: smoking (Yes/No), drinking (Yes/No), exercise (Never/Occasionally/Often).

2.5 | Blood pressure measurement

1. Nurses measured the blood pressure by themselves, for they were skilled in blood pressure measurement technology and could ensure the accuracy of the blood pressure value.
2. The upper arm medical electronic sphygmomanometer certified by international standard scheme or mercury sphygmomanometer meeting the measurement standard were selected. Standard cuff with airbag length of 22-26 cm and width of 12 cm(large cuff for obese people or those with large arm circumference (>32 cm) were used, The airbag covered at least 80% of the upper arm.
3. Before measuring blood pressure, the participants were required to sit quietly and rest for at least 5 minutes, ban smoking, drinking coffee or tea within 30 minutes, and empty the bladder. The participants were seated with their backs to the chair and their upper arms bare. The arm position (brachial artery) was at the same level as the heart, and the right upper arm was selected for measurement.
4. The blood pressure was taken three times continuously. The measurement was taken every time with an interval of 1–2 minutes., The first blood pressure value was discarded and the average value of the second and third readings was selected.

The diagnostic criteria of hypertension were based on The Chinese Guideline for Hypertension Prevention and Treatment 2018.[10] Hypertension was defined as systolic blood pressure at least 140 mmHg and/or diastolic pressure at least 90 mmHg or currently have been taking antihypertensive medications.

2.6 | Statistical analysis

The normal distribution of the continuous variables were tested and were represented by Median(Quartile Range) [M(QR)]. Categorical variables were shown as count (percentage). To avoid the interference from confounding factors and strong collinearity variables, logistic regression (stepwise) was used to analyze the data.

Taking whether diagnosed as hypertension as the dependent variable, logistic regression was used to establish two kinds of models. Model 1: Two categorical variables, age and night shift frequency, were respectively forced into the model by the Logistic Regression. As independent variables, other confounding factors were also included in the model. Statistically significant factors were included in the model by Logistic regression (Stepwise Method). Model 2: The total data set was split into nine subdatasets. In each subdataset, the lowest age (18-25) with the lowest night shift frequency (0) was taken as the reference group, 3 dummy variable groups were set as the contrast groups according to whether they were exposed to higher age and night shift frequency. The detailed group and variable assignments were shown in the supplement material. The Odds Ratio (OR) of the three dummy variables was the main effect of the age, night shift frequency, and the effect of their coexistence. An excel table made by Andersson[11] was applied to calculate the relative excess risk of interaction (RERI), the

attributable proportion of interaction (API) and the synergy index(SI), and its 95% confidence interval. RERI reflected the difference between the sum of combined action and single action of two factors. API reflected the proportion of the interaction effect of two factors in the total effect. SI reflected the sum of the combined effects of the two factors. If the confidence interval of RERI and API range did not include 0, and corresponding SI range did not include 1, then judge that their additive interactions were with statistical significance. IBM SPSS26.0 was used for statistical analysis and P less than .01 was considered statistically significant.

2.7 | Ethical review

This study has been reviewed and approved by the Ethics Committee of The Second Hospital of Hebei Medical University(2016225). Informed consent has been taken from all participants.

3 | RESULTS

3.1 | Basic information

By the end of the questionnaire recovery, there were 143 772 registered nurses in Hebei province in total. One lakh thirty-five thousand one hundred ninety-seven questionnaires were covered in this survey. The questionnaire recovery rate was 94.04%. If there existed missing data in the key variables "age, night shift frequency, hypertension diagnosis related factors," the corresponding questionnaires were excluded, for they were all key variables in this research. After integrity verification, 128 009 valid questionnaires were retained, and the effective recovery rate was 94.68%. After excluding the data of male nurses and performing logical verification, 121 903 questionnaires of female nurses were included for evaluation. Characteristics of study participants were shown in the Table 1.

3.2 | The influence of age on the prevalence of hypertension

The results showed that, compared with the age of 18–25, the age of 26–35, 36–45, and 46–65 were all risk factors for hypertension, and the OR value increased with age. See Table 2 for multivariate analysis results.

3.3 | The influence of night shift work frequency on the prevalence of hypertension

The results showed that, compared with those who had no night shift in recent six months, having more than 5–10 as well as more than 10 night shifts per month were both risk factors of hypertension, and their OR value increased with the night shift frequency, though the magnitude

of this increase was small. See Table 3 for the results of multivariate analysis.

3.4 | The interaction between age and night shift frequency on the prevalence of hypertension

The results showed by Table 4 demonstrated that, compared with those aged 18–25 who had no night shift, the interaction between 36-45 years old and more than 5–10 night shifts per month in recent six months was statistically significant, with an OR value of 2.923(95%CI 2.292-3.727). That was, the risk of the ones aged 36–45 with more than 5–10 night shifts per month was 2.923 times than that of the 18–25 ones with no night shift work. RERI was 0.631(95%CI 0.309-0.954), that meant the difference between the interaction effect of 36–45 years old with more than 5–10 night shifts per month and the sum of their individual effects was 0.631. API was 0.216 (95%CI 0.109-0.323), indicating that when the average night shift for 36–45 years old ones was more than 5–10, the pathogenic effect due to interaction effect accounted for 21.6% in hypertension prevalence. The SI was 1.488(95%CI 1.158-1.913), that is, the effect was 1.488 times higher than that of 36–45 years old and more than 5–10 night shifts.

Compared with those aged 18–25 who had no night shift, the interaction between 36-45 years old and more than 10 night shifts per month in recent six months was statistically significant, with an OR value of 3.430 (95%CI 2.273-5.175). That was, the risk of the ones aged 36–45 with more than 10 night shifts per month was 3.430 times than that of the 18–25 ones with no night shift work. RERI was 1.037 (95%CI 0.061-2.013), that meant the difference between the interaction effect of 36–45 years old with more than 10 night shifts per month and the sum of their individual effects was 1.037. API was 0.303 (95%CI 0.089-0.516), indicating that when the average night shift for 36–45 years old ones was more than 10, the pathogenic effect due to interaction effect accounted for 30.3% in hypertension prevalence. The SI was 1.746 (95%CI 1.093-2.788), that is, the effect was 1.746 times higher than that of 36–45 years old and > 10 night shifts.

Compared with those aged 18–25 who had no night shift, the interaction between 46-65 years old and more than 5–10 night shifts per month in recent six months was statistically significant, with an OR value of 7.398 (95%CI 5.595-9.781). That is, the risk of the ones aged 46–65 with more than 5–10 night shifts per month was 7.398 times than that of the 18–25 ones with no night shift work. RERI was 1.809 (95%CI 0.880-2.739), that meant the difference between the interaction effect of 46–65 years old with more than 5–10 night shifts per month and the sum of their individual effects was 1.809. API was 0.245 (95%CI 0.148-0.341), indicating that when the average night shift for 46–65 years old ones was more than 5–10, the pathogenic effect due to interaction effect accounted for 24.5% in hypertension prevalence. The SI was 1.394 (95%CI 1.199-1.622), that is, the effect was 1.394 times higher than that of 46–65 years old and more than 5–10 night shifts.

TABLE 1 Characteristics of study participants (No. = 121 903)

Items		No.	Percentage (%)
Age (years, median [IQR])	30 (27-35)	–	–
BMI (kg/m², median [IQR])	22.3(20.2-24.6)	–	–
Times of pregnancy (times, median [IQR])	1(0-2)	–	–
Times of deliveries (times, median [IQR])	1(0-1)	–	–
Times of abortion (times, median [IQR])	0(0-0)	–	–
Systolic Pressure	110(100-120)	–	–
Diastolic Pressure	70(63-80)	–	–
	Overall	121 903	100.00
Grade Of The Hospital	Missing Data	440	0.36
	Primary Hospital	7181	5.89
	Secondary Hospital	62 495	51.27
	Tertiary Hospital	51 787	42.48
Location Of The Hospital	Shijiazhuang	25 470	20.89
	Baoding	15 808	12.97
	Cangzhou	11 385	9.34
	Chengde	4555	3.74
	Handan	14 278	11.71
	Hengshui	5362	4.40
	Langfang	7886	6.47
	Qinhuangdao	6731	5.52
	Tangshan	15 254	12.51
	Xingtai	8944	7.34
	Zhangjiakou	6230	5.11
Department	Inner Medicine	36 540	29.97
	Surgery	22 520	18.47
	Gynecology	13 455	11.04
	Pediatrics	8674	7.12
	Emergency	6028	4.94
	Operation Room	5650	4.64
	Intensive Care Unit	5157	4.23
	Clinic	4574	3.75
	ENT	3062	2.51
	Administration And Logistics	3221	2.64
	Medical Technology	3081	2.53
	Others	9941	8.16
Age	18-25	22 016	18.06
	26-35	70 718	58.01
	36-45	20 319	16.67
	46-65	8850	7.26
BMI	Missing Data	178	0.15
	Underweight	9885	8.11
	Normal	75 456	61.90
	Overweight	28 213	23.14
	Obese	8171	6.70

(Continues)

TABLE 1 (Continued)

Items		No.	Percentage (%)
Average monthly frequency of night shift	0	42 318	34.71
	(0,5]	27 467	22.53
	(5,10]	47 013	38.57
	>10	5105	4.19
SBP < 140 mmHg and/or DBP < 90 mmHg	No	6266	5.14
	Yes	115 637	94.86
Whether taking hypertensive medicine	Missing Data	10	0.01
	No	118 470	97.18
	Yes	3423	2.81
The years of hypertension medical history	Missing Data	396	0.32
	0	117 054	96.02
	(0,5]	3 282	2.70
	(5,10]	799	0.65
	>10	372	0.31
Hypertension	No	114 287	93.75
	Yes	7616	6.25
Hyperlipidemia	Missing Data	436	0.36
	No	114 225	93.70
	Yes	7242	5.94
Diabetes	Missing Data	103	0.08
	No	120 661	98.98
	Yes	1139	0.94
Educational background	Specialist Qualification	61 927	50.80
	Bachelor degree	59 480	48.79
	Graduate	496	0.41
Marital Status	married	92 890	76.20
	unmarried	27 258	22.36
	Divorced Or Widowed	1755	1.44
History Of Oral Contraceptive Use	Missing Data	8	0.01
	No	115 108	94.42
	Yes	6787	5.57
Gestational Hypertension	Missing Data	12 310	10.10
	No	68 900	56.52
	Yes	3743	3.07
	No history of labor	36 950	30.31
History Of Hormone Replacement Therapy	Missing Data	44	0.04
	No	117 315	96.23
	Yes	4544	3.73
Menstrual Regularity	Missing Data	97	0.08
	Regular	90 317	74.09
	Irregular	27 716	22.73
	Menopausal	3773	3.10

(Continues)

TABLE 1 (Continued)

Items		No.	Percentage (%)
Smoking	No	120 213	98.61
	Yes	1690	1.39
Alcohol	No	61 041	50.07
	Yes	60 862	49.93
Exercise	Never	26 494	21.73
	Occasionally	85 317	69.99
	Often	10 092	8.28
Family History Of hypertension	No	62 450	51.23
	Yes	59 453	48.77

BMI, Body Mass Index; ENT, Ears, nose, and throat; IQR, Interquartile Range.

TABLE 2 The effect of age on hypertension prevalence (No. = 121 903)

	Hypertension					Adjusted OR		
Items	No	Yes	OR (95% CI)	Wald χ^2	P	(95%CI)*	Wald χ^2	P
Age								
[18,25]	21 501	515	1	–	<.001	1	–	<0001
[26,35]	68 125	2593	1.589 (1.144-1.749)	89.809		1.148 (1.020-1.293)	5.201	
[36,45]	18 092	2227	5.139 (4.660-5.667)	1074.939		3.127 (2.746-3.559)	296.792	
[46,65]	6569	2281	14.497 (13.124-16.014)	7003.87		6.462(5.618-7.433)	682.953	

*Adjusted for Social demographic information, personal history, and life habits.
CI, Confidence Intervals; OR, Odds Ratio.

TABLE 3 The effect of night shift frequency on hypertension prevalence (No. = 121 903)

	Hypertension					Adjusted OR		
Items	No	Yes	OR (95%CI)	Wald χ^2	P	(95%CI)*	Wald χ^2	P
Frequency Of Night Shift					<.001			.007
0	38 826	3492	1	–		1	–	
(0,5]	25 868	1599	0.687(0.646-0.731)	144.067		1.029(0.961-1.102)	0.659	
(5,10]	44 733	2280	0.567(0.537-0.598)	417.208		1.112(1.041-1.188)	9.948	
>10	4860	245	0.561(0.491-0.640)	72.866		1.160(1.003-1.342)	4.012	

*Adjusted for social demographic information, personal history, and life habits.
CI, Confidence Intervals; OR, Odds Ratio.

4 | DISCUSSION

4.1 | The overall risk of hypertension increases with age

This study found that the risk of hypertension in this population increased with age, which was consistent with the results of previous research.[10] Besides, it should also be acknowledged that perhaps women with a high level of ambition and who may be prone to hypertension are more likely to choose nursing as their carer. Based on this, as the age increases, the elasticity of the carotid artery wall was grad-

ually decreased. Simultaneously, the inner membrane was thickened, estrogen level in postmenopausal women declines, which would easily lead to increase of blood cholesterol, triglyceride, and other lipid metabolism disorders.

4.2 | Specific night shift frequency increase the risk of hypertension

Compared with those who have no night shift, those who are with more than 5–10 and more than 10 night shifts were more likely to have

TABLE 4 The effect of additive interaction between age and frequency of night shift work on hypertension (Np. = 121903)

Group	Items	Adjusted OR (95%CI)*	Wald χ^2	P	REPI (95%CI)	API (95%CI)	SI (95%CI)
1	18-25 years old with no night shift	1.000			0.296 (0.093–0.498)	0.303 (0.072–0.535)	0.080 (0.000–19.982)
	18-25 years old with >0-5 night shifts	0.817 (0.35–1.051)	2.473	.116			
	26-35 years old with no night shift	0.862 (0.707–1.050)	2.184	.139			
	26-35 years old with >0-5 night shifts	0.975 (0.801–1.186)	0.066	.798			
2	18-25 years old with no night shift	1.000			0.456 (0.305–0.607)	0.471 (0.274–0.668)	0.065 (0.001–6.530)
	18-25 years old with >5-10 night shifts	0.790 (0.653–0.956)	5.877	.015			
	26-35 years old with no night shift	0.722 (0.583–0.894)	8.887	.003			
	26-35 years old with >5-10 night shifts	0.968 (0.809–1.159)	0.123	.725			
3	18-25 years old with no night shift	1.000			0.551 (0.197–0.905)	0.487 (0.183–0.791)	−0.315**
	18-25 years old with >10 night shifts	0.843 (0.683–1.041)	2.525	.112			
	26-35 years old with no night shift	0.737 (0.476–1.141)	1.876	.171			
	26-35 years old with >10 night shifts	1.132 (0.871–1.471)	0.862	.353			
4	18-25 years old with no night shift	1.000			0.304 (−0.058–0.665)	0.103 (−0.019–0.234)	1.183 (0.951–1.473)
	18-25 years old with >0-5 night shifts	0.769 (0.599–0.989)	4.202	.04			
	36-45 years old with no night shift	2.887 (2.207–3.775)	59.903	<.001			
	36-45 years old with >0-5 night shifts	2.960 (2.224–3.904)	59.003	<.001			
5	18-25 years old with no night shift	1.000			0.631 (0.309–0.954)	0.216 (0.109–0.323)	1.488 (1.158–1.913)
	18-25 years old with >5-10 night shifts	0.681 (0.550–0.844)	12.33	<.001			
	36-45 years old with no night shift	2.612 (2.063–3.306)	63.756	<.001			
	36-45 years old with >5-10 night shifts	2.923 (2.292–3.727)	74.826	<.001			
6	18-25 years old with no night shift	1.000			1.037 (0.061–2.013)	0.303 (0.089–0.516)	1.746 (1.093–2.788)
	18-25 years old with >10 night shifts	0.659 (0.426–1.020)	3.499	.061			
	36-45 years old with no night shift	2.731 (2.104–3.545)	57.042	<.001			
	36-45 years old with >10 night shifts	3.430 (2.273–5.175)	34.462	<.001			

(Continues)

TABLE 4 (Continued)

Group	Items	Adjusted OR (95%CI)*	Wald χ^2	P	REPI (95%CI)	API (95%CI)	SI (95%CI)
7	18-25 years old with no night shift	1.000			−0.463 (−1.153–0.227)	−0.078 (−0.199–0.043)	0.914 (0.799–1.046)
	18-25 years old with >0-5 night shifts	0.780 (0.612–0.994)	4.047	.044			
	46-65 years old with no night shift	6.619 (5.241–8.360)	251.703	<.001			
	46-65 years old with >0-5 night shifts	5.935 (4.595–7.665)	186.217	<.001			
8	18-25 years old with no night shift	1.000			1.809 (0.880–2.739)	0.245 (0.148–0.341)	1.394 (1.199–1.622)
	18-25 years old with >5-10 night shifts	0.675 (0.545–0.836)	13.003	<.001			
	46-65 years old with no night shift work	5.910 (4.638–7.532)	206.347	<.001			
	46-65 years old with >5-10 night shifts	7.398 (5.595–9.781)	197.257	<.001			
9	18-25 years old with no night shift	1.000			1.560 (−1.976–5.095)	0.211 (−0.167–0.589)	1.322 (0.759–2.301)
	18-25 years old with >10 night shifts	0.666 (0.430–1.031)	3.324	.068			
	46-65 years old with no night shift	6.179 (4.734–8.065)	179.504	<.001			
	46-65 years old with >10 night shifts	7.407 (3.944–13.910)	38.776	<.001			

API, The Attributable Proportion of Interaction; CI, Confidence Intervals; OR, Odds Ratio; RERI, Relative Excess Risk of Interaction; SI, The Synergy Index.
*Adjusted for Social demographic information, personal history, and life habits.
**The excel table made by Andersson[12] did not give its confidence intervals.

hypertension. Their risks were 1.112 and 1.160 times of those who were without night shift, respectively. Though the increase is slight, that indicates night shift could add the risk of hypertension, which was consistent with some previous studies.[11-13]

First, night shift workers were frequently exposed to artificial light at night. That leaded to a lower level of a blood-pressure-lowering hormone circulating melatonin.[14] Second, the night shift provided opportunities to drink strong tea, use caffeine,[15] and have an irregular diet. Besides, studies had shown that the behaviors of night shift workers, such as smoking,[16] was relatively common, which was risk factors of hypertension. Finally, there was occupational stress in the night shift working population, which increased the risk of hypertension.[17-19] However, Sfreddo and associates[20] found that night shift work was not an influential factor of hypertension, which was inconsistent with the results of this study. It might be due to the small sample size of that study and the regular shift schedule that made nursing staff adapt their life pattern to the change of biological clock.[21] In that way, the disruption of circadian rhythm was decreased, the relationship between night shift and hypertension was weakened.

4.3 | There existed an additive interaction between age and night shift frequency on the prevalence of hypertension

The results of this study suggested that additive interaction effect existed between more than 5–10 as well as over 10 night shifts and the age of 36–45 years old, more than 5–10 night shifts and the age of 46–65. Compared with people aged 18–25 years who had no night shift work, the coexistence of the two factors could increase the prevalence of hypertension.

Most of the current studies focused on the separate effects of age and night shift on hypertension. Some studies had shown[22] that night shift can accelerate biological age of the human body, thus increasing the risk of diseases related to age increase.

In this study, the risk of hypertension among people aged 36–45 increased with night shift frequency, there might exist a cumulative effect on physical damage with the increase of age and working seniority.

For the ones who aged 46–65, the age itself was already a risk factor of hypertension. Women in this age group tended to be

perimenopausal or postmenopausal. While menopause is associated with changes consistent with cardiovascular aging.[23] In consequence, their ovarian function gradually decreased.[24] That would lower the estrogen which could promote smooth muscle relaxation, dilate blood vessels and potential resistance to oxidative stress damage.[25] In addition, the elderly tended to be exposed to night shifts for a longer time. As a result, the healthy advantage of night shift workers decreased, and the risk of hypertension increased. At present, however, there existed few studies concerning the interaction of the frequency of shifts shift and age on hypertension prevalence. More studies should be carried out to explore their interaction.

Nursing managers should pay attention to the health of nursing staff, and adopt scientific management methods to arrange different night shifts for female nursing staff of different ages.

4.4 | Advantages and limitations of the research

This study has several advantages. First, this study was conducted by census and had a large sample size, so the results were more reliable and representative than previous small-sample studies. Second, many specific factors of females were included to control confounding factors, making the results more accurate. Third, this study presented the influence of the interaction between different age groups and different night shift frequencies on the hypertension prevalence, which could provide some advice for nursing managers to arrange proper night shift frequency for women of different ages. Finally, this study used an additive interaction model to evaluate the interaction between age and night shift frequency, which could reflect the interaction mechanism in aspect of biological etiologies, rather than using the simple statistical interaction presented by the multivariate interaction model. In this way, we could explain the research results more objectively and comprehensively.

However, this study had some limitations. First, this study was a cross-sectional survey, which was inevitably unable to determine the causal relationship between exposure factors and outcomes, and the participants might have recall bias while filling in the questionnaire information. Second, dietary habits(such as high-salt diet), social status, economic income, and other economic and sociological factors that might be weakly related to blood pressure as well as shift scheduling patterns, years of rotating shift work and work intensity were not collected. Third, there might exist a healthy worker effect in the study. The nursing staff with poor health conditions might be arranged to other posts or have already retired. As a consequence, the results of the study might underestimate the adverse effects of night shift work on hypertension.

In the future, prospective cohort studies could be conducted, and simultaneously collect dietary habits, shift scheduling patterns, and other factors that might influence blood pressure to make up for existing deficiencies.

5 | CONCLUSION

Additive interaction effect between age and shift frequency can affect hypertension prevalence in female nurses. While focusing on patients' health status, nurses should pay adequate attention to the health conditions of themselves. It was suggested that nursing managers can formulate scientific shift mode according to nurses' age, which can not only ensure continuous and comprehensive health services for patients, but also reduce the influence of night shift work on the prevalence of hypertension among nurses.

CONFLICT OF INTEREST
There are no conflicts of interest.

AUTHOR CONTRIBUTIONS
W.C. conceived the study. W.C.,B.Z.,Y.H.,and Y.Z. designed the study,drafted the manuscript and critically revised the manuscript for important intellectual content. J.L., F.L., A.Z., X.Y., X.C., R.J., R.Z., A.F., Y.W., M.Y., S.C., J.C., M.Z.conducted the research and collected the data. X.H, D.F.,and M.X. collated the data, L.Y. and J.L. analyzed the data; W.C., B.Z., L.Y., and J.L. wrote this article. All authors read and approved the final manuscript.

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REFERENCES
1. Shan Z, Li Y, Zong G, et al. Rotating night shift work and adherence to unhealthy lifestyle in predicting risk of type 2 diabetes: results from two large US cohorts of female nurses. *BMJ*. 2018;363:k4641.
2. Cheng ML, Tseng YH, Hodges E, Chou FH. Lived Experiences of Novice Male Nurses in Taiwan. *J Transcult Nurs*. 2018;29:46–53.
3. Arif S, Khokhar S. A historical glance: challenges for male nurses. *J Pak Med Assoc*. 2017;67:1889–1894.
4. Ma Y, Chen SC, Zeng H. Male student nurses need more support: understanding the determinants and consequences of career adaptability in nursing college students. *Nurse Educ Today*. 2020;91:104435.
5. Ha M, Park J. Shift work and metabolic risk factors of cardiovascular disease. *J Occup Health*. 2005;47(2):89–95.
6. Ferguson JM, Costello S, Neophytou AM, Balmes JR, Eisen EA. Night and rotational work exposure within the last 12 months and risk of incident hypertension. *Scand J Work Environ Health*. 2019;45(3):256–266.
7. Manohar S, Thongprayoon C, Cheungpasitporn W, Mao MA, Herrmann SM. Associations of rotational shift work and night shift status with hypertension: a systematic review and meta-analysis. *J Hypertens*. 2017;35:1929–1937.
8. Hansen J, Stevens RG. Case–control study of shift-work and breast cancer risk in Danish nurses: impact of shift systems. *Eur J Cancer*. 2012;48(11):1722–1729.

9. Zhou BF, Cooperative Meta-Analysis Group of the Working Group on Obesity in China. Predictive values of body mass index and waist circumference for risk factors of certain related diseases in Chinese adults–study on optimal cut-off points of body mass index and waist circumference in Chinese adults. *Biomed Environ Sci*. 2002;15:83–96.

10. 2018 Chinese guidelines for the management of hypertension. *Chin J Cardiovasc Med*. 2019;24:24–56.

11. Nazri SM, Tengku MA, Winn T. The association of shift work and hypertension among male factory workers in Kota Bharu, Kelantan, Malaysia. *Southeast Asian J Trop Med Public Health*. 2008;39:176–183.

12. Lo SH, Lin LY, Hwang JS, Chang YY, Liau CS, Wang JD. Working the night shift causes increased vascular stress and delayed recovery in young women. *Chronobiol Int*. 2010;27:1454–1468.

13. Rotenberg L, Silva-Costa A, Vasconcellos-Silva PR, Griep RH. Work schedule and self-reported hypertension – the potential beneficial role of on-shift naps for night workers. *Chronobiol Int*. 2016;33:697–705.

14. Bhatti P, Mirick DK, Randolph TW, et al. Oxidative DNA damage during night shift work. *Occup Environ Med*. 2017;74:680–683.

15. Books C, Coody LC, Kauffman R, Abraham S. Night Shift Work and Its Health Effects on Nurses. *Health Care Manag (Frederick)*. 2017;36(4):347–353.

16. Park J, Shin SY, Kang Y, Rhie J. Effect of night shift work on the control of hypertension and diabetes in workers taking medication. *Ann Occup Environ Med*. 2019;31:e27.

17. Alves MGDM, Chor D, Faerstein E, Werneck GL, Lopes CS, Estresse no trabalho e hipertensão arterial em mulheres no Estudo Pró-Saúde: Estudo Pró-Saúde (Pro-Health Study) [J]. *Revista de Saúde Pública*, 2009;43(5):893–896.

18. Babu GR, Jotheeswaran AT, Mahapatra T, et al. Is hypertension associated with job strain? A meta-analysis of observational studies. *Occup Environ Med*. 2014;71:220–227.

19. Landsbergis PA, Dobson M, Koutsouras G, Schnall P. Job Strain and Ambulatory Blood Pressure: a Meta-Analysis and Systematic Review. *Am J Public Health*. 2013;103:e61–e71.

20. Sfreddo C, Fuchs SC, Merlo AťR, Fuchs FD. Shift Work Is Not Associated with High Blood Pressure or Prevalence of Hypertension. *PLoS ONE*. 2010;5:e15250.

21. Kalmbach DA, Pillai V, Cheng P, Arnedt JT, Drake CL. Shift work disorder, depression, and anxiety in the transition to rotating shifts: the role of sleep reactivity. *Sleep Med*. 2015;16:1532–1538.

22. White AJ, Kresovich JK, Xu Z, Sandler DP, Taylor JA. Shift work, DNA methylation and epigenetic age. *Int J Epidemiol*. 2019;48:1536–1544.

23. Nair AR, Pillai AJ, Nair N. Cardiovascular Changes in Menopause. *Curr Cardiol Rev*. 2021;17(4):e230421187681.

24. Augoulea A, Moros M, Lykeridou A, Kaparos G, Lyberi R, Panoulis K. Psychosomatic and vasomotor symptom changes during transition to menopause. *Prz Menopauzalny*. 2019;18(2):110–115.

25. Stevenson JC, Tsiligiannis S, Panay N. Cardiovascular Risk in Perimenopausal Women. *Curr Vasc Pharmacol*. 2019;17(6):591–594.