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Gender and Occupational Tenure as Independent Risk Factors for Thyroid Abnormalities among Radiology Workers

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ABSTRACT

Objective To evaluate sex-specific susceptibility and the impact of occupational tenure on thyroid health in radiology workers. **Subjects and Methods** A total of 385 radiological workers, who had been working at Nanjing Drum Tower Hospital from January 2024 to December 2024, were enrolled in the study (172 males, 139 females). Basic information, data on thyroid function, and ultrasonic thyroid test results were collected. **Results** The number of patients with abnormal thyroid function was not significantly different among radiological workers with different work statuses and working ages. However, working age (> 20 years) was found to be an independent risk factor for abnormal thyroid morphology. Additionally, female radiologists had significantly greater rates of abnormal thyroid function than male radiologists did. Sex (female) was also identified as an independent risk factor for abnormal thyroid morphology in radiological workers. **Conclusion** Female radiology workers exhibit increased susceptibility to radiation-induced thyroid dysfunction and morphological abnormalities, whereas prolonged occupational exposure (>20 years) independently predicts structural changes.

1. Introduction

With the development of science and medical technology, radiological diagnosis and treatment have become integral parts of clinical diagnosis and treatment [1][2]. Currently, numerous medical teams in China use radiation technology for treatment, leading to an annual increase in the utilization rate of radiation medical equipment and the number of radiation workers. Consequently, the impact of long-term exposure to low-dose radiation on the health of these workers has become a major concern in radiation diagnosis and treatment [3][4]. The thyroid gland is particularly susceptible to radiation, with prolonged exposure potentially leading to abnormal thyroid function or morphology, as well as the development of thyroid nodules, tumors, and other related diseases [5][6]. We therefore conducted a cross-sectional study to (1) quantify sex-stratified risk factors; (2) determine the dose–response relationships between occupational tenure and thyroid outcomes; and (3) identify independent predictors of thyroid morbidity.

2. Study design and patients

We enrolled 385 radiology workers from Nanjing Drum Tower Hospital (January–December 2024), comprising 311 active staff and 74 preemployment candidates. The participants (172 males, 139 females) aged 21–60 years (mean ± SD: 36.42 ± 8.86) met the following criteria: (1) they were radiological staff of Nanjing Drum Tower Hospital, who conducted physical examinations at Nanjing Occupational Disease Prevention and Control Hospital from January 2024 to December 2024; (2) they had no history of thyroid disease or related surgical interventions; (3) they had no history of heart, liver, gallbladder, kidney, or other significant organ disease, as well as other unstable physical conditions or defects; and (4) they had

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not used hormones or other medications affecting metabolism within the past six months.

This study was approved by the Ethics Committee of Nanjing Prevention and Treatment Center for Occupational Diseases. Informed consent was not required because the study was retrospective with no harm to patients, and all case data were anonymized.

All methods were carried out in accordance with relevant guidelines and regulations.

2.1. Thyroid function

Thyroid function was evaluated by measuring the serum levels of related items, and the detected items and corresponding reference values were as follows: thyroxine (T4, 66--181 μg/L), triiodothyronine (T3, 1.3--3.1 μg/L), thyrotropin (TSH, 0.27--4.2 mIU/L), free triiodothyronine (FT3, 3.1--6.8 pmol/L), free thyroxine (FT4, 12--22 pmol/L), anti-thyroglobulin antibody (TGAb, 0--115 IU/mL), and anti-thyroid peroxidase antibody (TPOAb, 0--34 IU/mL).

2.2. Thyroid morphometry

The thyroid status of the subjects was evaluated via high-frequency color Doppler ultrasound. The number, size, and TI-RADS grade of the nodules or cysts were recorded.

2.3. Statistical analysis

The chi-square test and logistic regression analysis were conducted with SPSS 25.0. The chi-square test was used for comparisons between groups, and $p < 0.05$ was considered statistically significant. Logistic regression analysis was used for multivariate analysis, the confidence level was 95%, the exclusion criterion was 0.1, and the test level was $\alpha = 0.05$.

3. Results

3.1. Comparison of radiology workers' thyroid function before and after work

Thyroid function parameters (T4, T3, TSH, FT3, FT4, TGAb, and TPOAb values) were not significantly different between preemployment workers and active workers (Table 1). However, preemployment individuals had higher subclinical abnormality rates for T4 (p=0.04) and TSH (p=0.01) (Table S1). This suggests that baseline screening may detect early subtle effects unrelated to occupational exposure.

Table 1 Comparison of seven thyroid function-related factors between radiologic workers who were preservice and those who were on-duty (mean±SE)

Iteams	Preservice	On duty	t value	p value
T4 (μg/L)	108.03±20.74	108.20±17.35	0.07	0.94
T3 (μg/L)	1.59±0.26	1.55±0.19	1.32	0.19
TSH (mIU/L)	2.39±1.30	2.19±1.58	1.03	0.31
FT3 (pmol/L)	4.84±0.69	4.67±0.64	1.98	0.06
FT4 (pmol/L)	18.89±2.22	19.13±1.95	0.93	0.35
TGAb (IU/mL)	18.47±33.92	32.11±96.63	1.20	0.23
TPOAb(IU/mL)	10.29±9.08	18.60±49.38	1.42	0.16

Table S1 Abnormal cases of seven items reflecting thyroid function in pre-service and on-duty radiology workers.

Iteams	Pre-service		On duty		χ^2	P
	Abnormal cases	Abnormal ratial	Abnormal cases	Abnormal ratial		
T4	1	1.35	0	0	4.21	0.04
T3	1	1.35	2	0.64	0.39	0.62
TSH	9	12.16	13	4.18	7.07	0.01
FT3	0	0	0	0	/	/
FT4	1	1.35	7	2.25	0.24	0.63
TGAb	1	1.35	19	6.11	2.75	0.10
TPOAb	4	5.4	20	6.43	0.11	0.74

3.2. Comparison of thyroid function among radiologic workers with varying years of work experience

We compared thyroid function among radiologic workers of different working ages, specifically investigating the occurrence of abnormal cases for seven items reflecting thyroid function. Our results, as presented in Table 2, revealed no significant differences in thyroid function among radiologic workers of different ages. Furthermore, the means of the values for the seven items reflecting thyroid function at different working ages did not significantly differ (Table S2).

Table 2 Abnormal cases of seven items reflecting thyroid function in different working ages

Working age(years)	T4 (cases)	T3 (cases)	TSH (cases)	FT3 (cases)	FT4 (cases)	TGAb (cases)	TPOAb (cases)
＜10	1	2	19	0	7	15	16
10~20	0	1	4	0	1	4	4
＞20	0	0	0	0	0	1	4
χ^2	0.54	0.48	4.41	/	2.01	1.24	1.05
p value	0.76	0.79	0.11	/	0.37	0.54	0.59

Table S2 Value of seven items reflecting thyroid function in radiology workers with different working ages（mean±SE）

Items	Working age (years)			F-value	P-value
	＜10	10~20	＞20		
T4 (μg/L)	109.26±18.69	105.93±15.58	106.57±18.62	1.33	0.27
T3 (μg/L)	1.57±0.22	1.54±0.17	1.56±0.19	0.99	0.37
TSH (mIU/L)	21.97±70.19	22.23±75.63	18.11±29.53	0.72	0.49
FT3 (pmol/L)	33.03±103.91	22.03±38.21	24.74±60.64	2.81	0.06
FT4 (pmol/L)	19.13±2.04	18.99±1.89	19.03±2.06	0.17	0.84
TGAb (IU/mL)	4.76±0.67	4.60±0.61	4.59±0.61	0.59	0.56
TPOAb(IU/mL)	2.29±1.17	2.17±2.44	2.02±0.68	0.07	0.94

3.3. Comparison of thyroid function between male and female radiologic workers

Sex is considered to be a vital influencing factor of thyroid function and radiation tolerance [7][8]. Here, the thyroid function of male and female radiologic workers was compared, and the values of seven items reflecting thyroid function were calculated. Table 3 indicates that there were significant differences in five of the tested items (T3, TSH, FT3, FT4, and TGAb) between male and female radiologic workers. Furthermore, the number of abnormal cases for TSH, TGAb, and TPOAb was significantly

greater in female radiologic workers than in male radiologic workers (Table S3).

Table 3 Comparison of thyroid function-related parameters between male and female radiologic workers

items	female	male	t value	p value
T4 (μg/L)	108.44±19.59	107.92±16.55	0.28	0.78
T3 (μg/L)	1.51±0.22	1.61±0.18	4.67	＜0.01
TSH (mIU/L)	2.51±2.01	1.98±0.84	3.40	＜0.01
FT3 (pmol/L)	4.31±0.53	5.05±0.55	13.45	＜0.01
FT4 (pmol/L)	18.47±2.12	19.63±1.74	5.90	＜0.01
TGAb (IU/mL)	46.26±125.15	14.61±19.08	3.57	＜0.01
TPOAb(IU/mL)	28.36±83.61	15.56±49.66	1.85	0.07

Table S3 Comparison of abnormal thyroid function cases between male and female radiology workers

Items	Female		Male		χ2	P
	cases	ratio	cases	ratio		
T4	0	0.00	1	0.49	0.89	0.35
T3	3	1.66	0	0.00	3.41	0.06
TSH	17	9.39	5	2.45	8.58	＜0.01
FT3	0	0.00	0	0.00	/	/
FT4	1	0.55	6	2.94	3.07	0.08
TGAb	17	9.39	3	1.47	12.22	＜0.01
TPOAb	17	9.39	7	3.43	5.83	0.02

3.4. Comparison of seven tested thyroid function-related items in radiological workers of different ages

According to previous studies, radiation-induced diseases are closely related to patient age [9][10]. In this study, we found a correlation between the age of radiologic workers and their FT3 and FT4 values (p<0.05, Table 4). However, there was no significant difference in the number of abnormal cases for the tested thyroid function-related items among the different age groups (p>0.05, Table S4).

Table 4 Relationships between age and thyroid function

Items	age (years)			F	p value
	＜30	30-50	＞50		
T4 (μg/L)	108.26±20.30	108.23±16.72	107.47±20.68	0.03	0.97
T3 (μg/L)	1.60±0.25	1.55±0.19	1.53±0.17	2.92	0.06
TSH (mIU/L)	2.47±1.20	2.12±1.69	2.34±1.02	1.87	0.16
FT3 (pmol/L)	4.89±0.64	4.69±0.64	4.27±0.59	12.98	＜0.01
FT4 (pmol/L)	19.17±2.13	19.18±1.92	18.23±2.15	3.81	0.02
TGAb (IU/mL)	32.62±71.50	29.64±99.28	20.30±26.73	0.26	0.77
TPOAb(IU/mL)	23.21±71.59	21.53±70.67	17.65±30.60	0.09	0.92

Table S4 Abnormal cases of seven items reflecting thyroid function in different ages

items	＜30 years old		30-50 years old		＞50 years old		χ2	P
	Cases (n)	Ratio (%)	Cases (n)	Ratio (%)	Cases (n)	Ratio (%)		
T4	1	1.04	0	0.00	0	0.00	3.02	0.22
T3	1	1.04	2	0.79	0	0.00	0.38	0.83
TSH	10	10.42	10	3.97	2	5.41	5.37	0.07
FT3	0	0.00	0	0.00	0	0.00	/	/
FT4	3	3.13	4	1.59	0	0.00	1.68	0.43
TGAb	7	7.29	12	4.76	1	2.70	1.42	0.49
TPOAb	7	7.29	13	5.16	4	10.81	2.01	0.37

3.5. Regression analysis of thyroid morphologic abnormalities (nodules, tumors, etc.) in radiological workers

The multivariate regression analysis results in Table 5 indicate that sex (female sex) (OR=0.41, p=0.011) and working age (> 20 years) (OR=2.05, p=0.002) are independent risk factors for abnormal thyroid morphology (such as nodules and tumors) among radiological staff at Nanjing Drum Tower Hospital.

Table 5 Logistic regression analysis of factors influencing abnormal thyroid morphology

	β	SE	WaldX^2	OR	95% *CI*	P
Gender (female)	0.89	0.35	6.45	0.41	0.21	0.011
Age (＞50 years)	0.12	0.34	0.12	0.89	0.46	0.725
Married	0.11	0.41	0.08	1.12	0.50	0.781
Working age (＞20 years)	0.72	0.23	9.57	2.05	1.30	0.002
On duty	0.54	0.36	2.33	0.58	0.29	0.127
Smoking	0.62	0.44	1.96	0.54	0.23	0.161
Drinking	0.30	0.32	0.84	1.35	0.71	0.360

4. Discussion

Previous studies have demonstrated that the impact of ionizing radiation on the human body is influenced by several factors, including the type of radiation, the specific organ and tissue exposed, and the duration of radiation exposure [11]. As one of the most important endocrine gland organs in the human body, the thyroid is very sensitive to ionizing radiation, which can result in thyroid functional and morphological diseases [12]. As radiological workers are always exposed to radiation, they are highly susceptible to thyroid-related diseases [12].

According to previous research, long-term exposure to low doses of ionizing radiation can potentially lead to thyroid diseases [13]. Previous research has indicated that several parameters, including thyroxine (T4), triiodothyronine (T3), thyrotropin (TSH), free triiodothyronine (FT3), free thyroxine (FT4), anti-thyroglobulin antibody (TGAb), and anti-thyroid peroxidase antibody (TPOAb), are utilized as fundamental indicators to evaluate thyroid function and diagnose radioactive thyroid diseases [14]. Here, we revealed no significant differences in thyroid function-related parameters between on-duty and preservice radiological workers (Table 1). Additionally, the number of patients with abnormal thyroid function did not significantly differ among radiological workers with different durations of employment (Table 2). However, Udiong reported that thyroid function is closely related to the age of individuals [15]. In this study, the mean values of thyroid function-related parameters were altered with changes in the age of the radiological workers, although the number of patients with abnormal

thyroid function did not significantly differ (Table 4 and Table S4). These findings indicate that radiological workers have taken adequate protection measures during their working hours, which have helped prevent the effects of long-term low-dose ionizing radiation on thyroid function. Understanding the potential damage caused by ionizing radiation, implementing protective measures, and continuously improving protective conditions are essential in this regard.

Additionally, multivariate logistic regression analysis revealed that working age (more than 20 years), such as the presence of nodules or tumors, is an independent risk factor for abnormal thyroid morphology. This suggests that the harm caused by low-dose radiation is subtle, and it may take years for thyroid morphology to exhibit signs of lesions under such conditions, which is consistent with previous studies [16][17]. These findings emphasize the importance of long-term monitoring and follow-up examinations for radiological workers to detect any potential adverse effects on thyroid health, even in the absence of significant changes in thyroid function parameters.

This study further investigated the impact of sex on the tolerance of thyroid irradiation. The results revealed that female radiologists had a significantly greater number of patients with abnormal TSH, TGAb, and TPOAb levels than male radiologists did, and the difference was statistically significant (Table 3). Multivariate logistic regression analysis also indicated that sex (female) is an independent risk factor for abnormal thyroid morphology in radiologists (Table 5), which aligns with previous research findings [18][19]. The greater risk of thyroid disease in women may be attributed to the more pronounced secretion of estrogen in the female body, which can promote the development of abnormal thyroid morphology [20].

In conclusion, this study conducted at Nanjing Drum Tower Hospital revealed a close relationship between thyroid function and sex among radiological workers. Female workers and those with more than 20 years of work experience were found to have a greater likelihood of developing thyroid nodules and tumors. Importantly, however, this study focused solely on thyroid function and morphology in radiological workers. Further research is needed to investigate the potential impact of low doses of radiation in the work environment on the overall physical and mental health of these workers.

Declarations

Authors' contributions

Bing Xu and Xiang Dong designed the research; Youjia Li performed the research and analyzed the data; Bing Xu and Youjia Li wrote the paper.

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Nanjing Prevention and Treatment Center for Occupational Diseases. Informed consent was not required because the study was retrospective with no harm to patients, and all case data were anonymized. The study was conducted in accordance with the Declaration of Helsinki.

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