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Analysis of Occupational Health Examination Results of Radiation Workers in Yangzhou in 2025

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Abstract: Objective: To assess the health status of 2,957 radiation workers who underwent occupational health examinations in Yangzhou in 2025, and to explore the health effects of low-dose ionizing radiation. Methods: A cross-sectional survey was conducted, and the health examination data were statistically analyzed. Results: Significant differences in abnormal rates were observed among different genders, ages, job types, and examination types ($P < 0.05$). The highest abnormal rate was found in electrocardiogram (41.56%), followed by liver function (16.44%) and blood pressure (16.03%). The abnormal rates of lens, blood pressure, electrocardiogram, and nails increased with age. Conclusion: Long-term exposure to low-dose ionizing radiation has adverse effects on the health of radiation workers, underscoring the necessity of strengthening occupational health protection.

Keywords: Radiation workers; Occupational health examination; Ionizing radiation; Health effects

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1. Introduction

With the widespread application of radiation technology in medical, industrial, and other fields, the number of radiation workers has been increasing year by year. To safeguard their health, the "Basic Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources" (GB 18871-2002) stipulates that the average annual effective dose for radiation workers over five consecutive years should not exceed 20 mSv, with no single year exceeding 50 mSv [1]. In recent years, with enhanced awareness of radiation protection and improved protective measures, the radiation doses received by radiation workers have significantly decreased [2]. However, due to the unique nature of their occupation, radiation workers remain chronically exposed to low-dose ionizing radiation environments, making regular health risk assessments essential [3]. This study analyzes the occupational health examination results of 2,957 radiation workers in Yangzhou City in 2025, exploring the impact of different factors on their health status to provide a basis for formulating scientific protective strategies.

2. Objects and methods

2.1. Research objects

Select radiation workers who participated in occupational health examinations in 2025, including 2,083 males and 874 females, with a gender ratio of 2.4:1 and an average age of (39.86 ± 10.96) years. Among them, there were 1,972 medical application personnel and 985 non-medical application personnel; 372 individuals were pre-employment personnel, while 2,585 were on-the-job or off-the-job personnel.

2.2. Methods

Data on general conditions, ophthalmology, electrocardiogram (ECG), dermatology, and laboratory tests (including thyroid function, blood routine, and blood biochemistry) were collected. Health examinations and result evaluations were conducted in accordance with the "Health Requirements and Monitoring Specifications for Radiation Workers" (GBZ 98-2020).

2.3. Statistical processing

Data were organized using Excel, and statistical analysis was performed using SPSS 19.0. The trend x^2 test was used to compare abnormal rates across age strata, while the x^2 test was used to compare abnormal rates between other groups. A statistically significant difference was considered when $P < 0.05$.

3. Results

3.1. Analysis of basic conditions of physical examination indicators

The overall abnormal rate among radiation workers was 90.13%. The top five indicators with the highest abnormal rates were electrocardiogram (41.56%), liver function (16.44%), blood pressure (16.03%), platelets (15.96%), and lens (11.84%), as shown in **Table 1**.

Table 1. Basic conditions of physical examination indicators [n = 2,957]

Examination item	Normal count	Abnormal count	Abnormal rate (%)
White Blood Cells	2,648	309	10.45
Red Blood Cells	2,690	267	9.03
Hemoglobin	2,628	329	11.13
Platelets	2,485	472	15.96
Lens	2,607	350	11.84
Liver Function	2,471	486	16.44
Renal Function	2,945	12	0.41
Thyroid Function	2,875	82	2.77
Blood Pressure	2,483	474	16.03
Electrocardiogram	1,728	1,229	41.56
Nails	2,741	216	7.30

3.2. Analysis of abnormal physical examination indicators by gender

There were significant differences in the abnormal rates of multiple indicators between different genders ($P < 0.05$), as detailed in **Table 2**.

Table 2. Abnormal rates of physical examination indicators by gender [n(%)]

Evaluation index	Male (*n*=2083)	Female (*n*=874)	x^2 Value	*P*-value
White Blood Cells	167 (8.02)	142 (16.25)	44.562	<0.001
Red Blood Cells	145 (6.96)	122 (13.96)	36.703	<0.001
Hemoglobin	183 (8.79)	146 (16.70)	39.049	<0.001
Platelets	323 (15.51)	149 (17.05)	1.091	0.296
Lens	261 (12.53)	89 (10.18)	3.250	0.071
Liver Function	457 (21.94)	29 (3.32)	155.442	<0.001
Renal Function	417 (20.02)	19 (2.17)	155.970	<0.001
Thyroid Function	47 (2.26)	35 (4.00)	6.979	0.008
Blood Pressure	430 (20.64)	44 (5.03)	111.441	<0.001
Electrocardiogram	922 (44.26)	307 (35.13)	21.163	<0.001
Nails	188 (9.03)	28 (3.20)	30.818	<0.001

3.3. Analysis of abnormal physical examination indicators by age

As age increases, the abnormal rates of the lens, blood pressure, electrocardiogram, and nails among radiation workers show an upward trend ($P < 0.05$), as shown in **Table 3**.

Table 3. Abnormal rates of various indicators among different age groups [n(%)]

Evaluation index	18-	30-	40-	50-	60-	Trend x^2	*P*-value
White Blood Cells	56 (9.57)	101 (10.39)	93 (11.79)	53 (10.60)	6 (5.41)	0.000	0.983
Red Blood Cells	51 (8.72)	80 (8.23)	79 (10.01)	41 (8.20)	16 (14.41)	1.258	0.262
Hemoglobin	62 (10.60)	107 (11.01)	85 (10.77)	56 (11.20)	19 (17.12)	1.246	0.264
Platelets	93 (15.90)	139 (14.30)	130 (16.48)	82 (16.40)	28 (25.23)	3.280	0.070
Lens	56 (9.57)	70 (7.20)	79 (10.01)	95 (19.00)	50 (45.05)	87.882	<0.001
Liver Function	96 (16.41)	180 (18.52)	127 (16.09)	68 (13.60)	15 (13.51)	3.359	0.067
Renal Function	90 (15.39)	151 (15.53)	112 (14.20)	65 (13.00)	18 (16.22)	0.947	0.331
Thyroid Function	16 (2.74)	24 (2.47)	18 (2.28)	18 (3.60)	6 (5.41)	1.857	0.173
Blood Pressure	47 (8.03)	111 (11.42)	133 (16.86)	141 (28.20)	42 (37.84)	127.413	<0.001
Electrocardiogram	260 (44.44)	356 (36.63)	307 (38.91)	233 (46.60)	73 (65.77)	10.000	0.002
Nails	3 (0.51)	20 (2.06)	63 (7.98)	97 (19.40)	33 (29.73)	239.373	<0.001

3.4. Analysis of abnormal physical examination indicators by occupational category

There were statistically significant differences in the abnormal rates of hemoglobin, liver function, renal function, thyroid function, and electrocardiogram indicators among radiation workers of different occupational categories (*P*

< 0.05), as shown in **Table 4**.

Table 4. Abnormal rates of various indicators among different occupational categories [n(%)]

Evaluation index	Medical	Non-medical	x^2 Value	*P*-value
White Blood Cells	207 (10.50)	102 (10.36)	0.014	0.906
Red Blood Cells	176 (8.92)	91 (9.24)	0.079	0.779
Hemoglobin	200 (10.14)	129 (13.10)	5.799	0.016
Platelets	317 (16.08)	155 (15.74)	0.056	0.812
Lens	246 (12.47)	104 (10.56)	2.312	0.128
Liver Function	281 (14.25)	205 (20.81)	20.599	<0.001
Renal Function	251 (12.73)	185 (18.78)	19.149	<0.001
Thyroid Function	64 (3.25)	18 (1.83)	4.899	0.027
Blood Pressure	304 (15.42)	170 (17.26)	1.658	0.198
Electrocardiogram	779 (39.50)	450 (45.69)	10.337	0.001
Nails	141 (7.15)	75 (7.61)	0.209	0.648

3.5. Analysis of abnormal physical examination indicators by type of physical examination

There were statistically significant differences in the abnormal rates of blood pressure and nails among radiation workers undergoing different types of physical examinations ($P < 0.05$), as shown in **Table 5**.

Table 5. Abnormal rates of various indicators among different types of physical examinations [n(%)]

Evaluation index	Pre-employment	During employment	x^2 value	*P*-value
White Blood Cells	46 (12.37)	263 (10.17)	1.669	0.196
Red Blood Cells	38 (10.22)	229 (8.86)	0.728	0.393
Hemoglobin	47 (12.63)	282 (10.91)	0.979	0.322
Platelets	51 (13.71)	421 (16.29)	1.609	0.205
Lens	35 (9.41)	315 (12.19)	2.403	0.121
Liver Function	53 (14.25)	433 (16.75)	1.484	0.223
Renal Function	59 (15.86)	377 (14.58)	0.421	0.516
Thyroid Function	11 (2.96)	71 (2.75)	0.053	0.817
Blood Pressure	32 (8.60)	442 (17.10)	17.441	<0.001
Electrocardiogram	163 (43.82)	1066 (41.24)	0.891	0.345
Nails	4 (1.08)	212 (8.20)	24.388	<0.001

4. Discussion

Through a cross-sectional analysis of the occupational health examination results of 2,957 radiation workers in Yangzhou City, this study found a relatively high overall abnormality rate (90.13%) in this population, with the abnormality rates of multiple indicators being significantly correlated with gender, age, job type, and on-the-job status. This suggests that the impact of long-term low-dose ionizing radiation exposure on health is a multifactorial and gradual process, with varying risks among different subgroups, warranting in-depth exploration.

4.1. Core abnormal indicators highlight cardiovascular and metabolic burdens

In this study, the abnormality rate of electrocardiograms (41.56%) ranked highest, far exceeding other indicators, aligning with the trend of multiple recent studies focusing on the long-term effects of radiation on the cardiovascular system [4–5]. Combined with the fact that the abnormality rate of blood pressure (16.03%) also ranked among the highest, it suggests that long-term low-dose ionizing radiation may impose a sustained burden on the cardiovascular system of radiation workers. This impact may be related to radiation-induced chronic inflammatory responses, oxidative stress, and endothelial dysfunction. Therefore, in future occupational health monitoring, in addition to traditional blood tests and lens examinations, cardiovascular function assessment should be elevated to a more central position to enable early warning and intervention.

4.2. Gender differences reveal potential female sensitivity and key protection focuses

Regarding blood system indicators (white blood cells, red blood cells, hemoglobin), the abnormality rate among female workers is significantly higher than that among male workers, which echoes the conclusion of some studies that females are more genetically susceptible to radiation damage [6–7]. This finding holds significant practical implications: it suggests that when formulating protection strategies, male and female workers should not be regarded as a homogeneous group; instead, gender-specific risks should be considered. For instance, more targeted health education can be provided to female workers, and it can be explored whether differentiated management in terms of dose limits or frequency of medical examinations is necessary. This may represent an innovative direction worthy of in-depth exploration in the field of radiation protection in the future.

4.3. Job type differences reflect the effectiveness of protective behaviors and health management

The fact that the abnormality rate of key indicators such as liver function, renal function, and electrocardiograms among radiation workers in non-medical industries surpasses that in the medical industry is a thought-provoking discovery [8]. It may reveal significant disparities in protective behaviors and health management awareness across different work environments. Workers in the medical industry typically possess more professional knowledge about radiation, and the protective supervision in their workplaces is also more stringent and standardized. Conversely, some non-medical industries (such as industrial radiographic testing) may suffer from weak protective awareness and relatively lagging supervision [9–10]. Therefore, the focus of public health interventions should be expanded outward to strengthen supervision and training for non-medical radiation units, extending the “protection culture” from the medical field to all industries involving radiation.

4.4. Cumulative effects of age and length of service, and early intervention window in the radiation industry

The abnormality rates of the lens, blood pressure, electrocardiogram, and nails increase significantly with age, clearly demonstrating the superimposition of the cumulative effects of radiation exposure and the body’s natural aging process. In particular, the abnormality rate of the lens rises sharply after the age of 50, and the data from the city in 2025 (11.84%) shows a notable increase compared to that in 2015 (7.31%), sounding an alarm for protective measures. This emphasizes the necessity of providing focused monitoring for workers of advanced age and long service duration. Meanwhile, for younger workers, it is essential to make full use of the baseline data from “pre-employment physical examinations” and establish individualized health risk warning models by tracking the dynamic changes in early indicators such as nails and blood pressure during their on-the-job period, thus achieving a transition from “group protection” to “precise monitoring” [11–12].

4.5. Research limitations

This study is a cross-sectional survey, making it difficult to confirm the causal relationship between ionizing radiation and health abnormalities. Changes in abnormal indicators may be simultaneously influenced by various confounding factors such as age, lifestyle, mental stress, and genetic background. For example, the higher abnormal rates in liver function and blood pressure indicators among males may be related to occupational exposure, but they could also be associated with prevalent gender-based lifestyle differences. Future research should incorporate personal dose monitoring data and conduct prospective cohort studies to more precisely quantify risks.

5. Conclusion and outlook

In summary, the health impacts of long-term low-dose ionizing radiation on radiation workers in Yangzhou City exhibit multi-system and differentiated characteristics. To address this challenge, the following innovative and comprehensive measures are recommended: First, in terms of monitoring strategies, transition from “universal examinations” to “precision monitoring based on risk stratification”, with a focus on workers with long tenures, females, and those in non-medical industries. Second, in terms of protection, expand from “physical protection” to “behavioral and health management”, enhancing overall health literacy among practitioners through strengthened training and mental health support. Third, strengthen data integration; future research should combine health records with personal dose data to establish a dynamic risk assessment system, thereby ensuring more scientific and effective occupational health protection for radiation workers.

Disclosure statement

The authors declare no conflict of interest.

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