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Trends in Occupational Environmental Hazardous Factors and Health Damage: Based on Data from Yangzhou City over Three Years

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Abstract: *Objective*: To analyze the trends in occupational environmental hazardous factors and health damage, and to assess the degree of occupational health risks. *Methods*: A total of 1,733 occupational disease monitoring data points from workplaces collected by the Yangzhou Center for Disease Control and Prevention from January 2019 to December 2021 were selected to evaluate occupational hazard factors and occupational health risk levels. *Results*: Over the three-year period, there were 525 monitoring samples for dust exposure, with an exceedance rate of 1.71% (9/525); 791 monitoring samples for noise exposure, with an exceedance rate of 4.42% (35/791); and 417 monitoring samples for chemical toxins (exogenous) exposure, with an exceedance rate of 1.68% (7/417). A comprehensive evaluation of exceedance factors revealed that high-risk factors included silica dust and benzene, classified as Level 4, while medium-risk factors encompassed manganese and xylene, including their compounds, classified as Level 3. *Conclusion*: After long-term monitoring of multiple workplaces in the city, it was found that there were certain occupational hazard factors, specifically involving dust or noise, as well as related factors of chemical toxins. Among these, silica dust and benzene posed the highest risks, while manganese and xylene also carried relatively high risks. It is necessary to strengthen occupational disease prevention and management to reduce the occurrence risks.

Keywords: Workplaces in Yangzhou city; Occupational diseases; Hazard factor monitoring; Occupational health risk assessment

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1. Introduction

Occupational diseases are illnesses contracted by workers in various enterprises or individual economic organizations during occupational activities due to prolonged exposure to dust or chemical toxins, or prolonged interference from noise, psychological factors, and more. These diseases exhibit diverse types and strong latent characteristics, posing long-term harm to the physical and mental health of workers [1]. The numerous hazard factors associated with occupational diseases, such as biological, chemical, or physical factors, and systematic and scientific prevention and control measures can be employed to prevent such diseases. In recent years, continuous innovations in industrial materials and technologies have significantly increased the risk of occupational diseases during production and processing, leading to the emergence of various occupational health issues that have garnered significant attention from disease control and prevention centers.

To address this, this study selected 1,733 occupational disease monitoring data points from Yangzhou City, comprehensively screened the hazardous factors contributing to occupational diseases, and assessed the degree of occupational health risks.

2. Materials and methods

2.1. General information

This study selected 1,733 occupational disease monitoring data points from workplaces collected by the Yangzhou City Center for Disease Control and Prevention between January 2019 and December 2021.

Specifically, there were 186 monitoring data points for dust exposure, 209 for noise exposure, and 132 for chemical toxicants (exogenous) exposure in 2019; 201 for dust exposure, 375 for noise exposure, and 141 for chemical toxicants (exogenous) exposure in 2020; and 138 for dust exposure, 207 for noise exposure, and 144 for chemical toxicants (exogenous) exposure in 2021. In total, there were 525 data points for dust exposure, 791 for noise exposure, and 417 for chemical toxicants (exogenous) exposure.

2.2. Methods

Monitoring data from various workplaces collected by the Yangzhou City Center for Disease Control and Prevention were selected, and data on occupational disease hazard factors were extracted. These data were then comprehensively analyzed in conjunction with quality control data compiled by the Yangzhou Occupational Health Technical Quality Control Center. The "Occupational Exposure Limits for Hazardous Factors in the Workplace" was chosen as a reference, with its first part covering chemical hazardous factors and the subsequent part addressing physical factors. Based on the content of this document, a comprehensive assessment of corresponding exceedance situations was conducted. Adhering to relevant assessment guidelines, a semi-quantitative assessment method was employed, utilizing the exposure index method during the evaluation of occupational health risks.

By applying standardized evaluation guidelines, toxicological and occupational health data are systematically collected, organized, and analyzed in order to comprehensively assess the risks posed by chemical hazardous factors. The assessment framework begins with the determination of the hazard rating (HR), which reflects the intrinsic toxicological properties of the chemical under consideration. This rating synthesizes evidence from toxicological studies, existing exposure limits, and established classifications of hazardous substances. To complement the hazard-based evaluation, an exposure index (EI) is calculated. This parameter accounts for critical factors that influence actual workplace exposure, including the daily usage amount, the physical and chemical characteristics of the substance including volatility, particle size, aerodynamic diameter, or steam pressure, and the duration and frequency of worker contact with the substance. Where multiple exposure determinants are present, the exposure rating (ER) is derived using the formula $(EI1 \times EI2... Ein)^{(1/n)}$.

Based on the exposure dose, Level 1 indicates extremely low exposure, while Level 5 indicates extremely high exposure. The number of exposure factors is denoted as n. The risk index (denoted as R) was calculated based on the HR and ER values using the formula (HR × ER) $^{(1/2)}$. The R value ranges from 1 to 5, with 1 indicating negligible risk and 5 indicating extremely high risk.

2.3. Statistical analysis

Data were processed using SPSS 28.0 software. Measurement values were compared and tested using *t*-values, while count values were compared/tested using χ^2 values. Statistical significance was considered when the *p*-value was less than 0.05.

3. Results

3.1. Analysis of exceedance rates of occupational disease hazard factors by year

The exceedance rate in 2021 was significantly lower than in other years (**Table 1, 2 and 3**). The exceedance rates for each hazard factor are as follows, with a comparison between years showing $p < 0.05$.

Table 1. Analysis of exceedance rates of dust exposed work by year (2019–2021)

Year	Dust exposed work		
	Monitoring points	Exceedance count	Exceedance rate (%)
2019	186	7	3.76
2020	201	2	1.00
2021	138	0	0.00
Total	525	9	1.71
χ^2		7.660	
p-value		0.022	

Note: Chi-square tests were used for inter-group comparisons.

Table 2. Analysis of exceedance rates of noise exposed work by year (2019–2021)

Year	Noise exposed work		
	Monitoring points	Exceedance count	Exceedance rate (%)
2019	209	17	8.13
2020	375	11	2.93
2021	207	7	3.38
Total	791	35	4.42
χ^2		9.304	
p-value		0.010	

Note: Chi-square tests were used for inter-group comparisons.

Table 3. Analysis of exceedance rates of chemical toxicant (exogenous) exposed work by year (2019–2021)

Year	Chemical toxicant (exogenous) exposed work		
	Monitoring points	**Exceedance count**	**Exceedance rate (%)**
2019	132	5	3.79
2020	141	2	1.42
2021	144	0	0.00
Total	417	7	1.68
χ^2		6.074	
p-value		0.048	

Note: Chi-square tests were used for inter-group comparisons.

3.2. Analysis of enterprise sizes with exceedance of hazard factors

Among the enterprise sizes with exceedance of hazard factors, large enterprises had the highest exceedance rate, followed by medium-sized and micro enterprises, with a comparison showing $p < 0.05$ (see **Table 4, 5 and 6**).

Table 4. Analysis of enterprise sizes with exceedance of dust exposed work

Scale	Dust-exposed work		
	Monitoring points	**Exceedance count**	**Exceedance rate (%)**
Large	94	7	7.45
Medium	171	1	0.58
Small	159	0	0.00
Micro	101	1	0.99
Total	525	9	1.71
χ^2		22.716	
p-value		0.000	

Table 5. Analysis of enterprise sizes with exceedance of noise exposed work

Scale	Noise-exposed work		
	Monitoring points	**Exceedance count**	**Exceedance rate (%)**
Large	293	10	3.41
Medium	191	18	9.42
Small	164	1	0.61
Micro	143	6	4.20
Total	791	35	4.42
χ^2		8.005	
p-value		0.046	

Table 6. Analysis of enterprise sizes with exceedance of chemical toxicant (exogenous) exposed work

Scale	Chemical toxicant (exogenous)-exposed work		
	Monitoring points	Exceedance count	Exceedance rate (%)
Large	148	5	3.38
Medium	100	1	1.00
Small	81	0	0.00
Micro	88	1	1.14
Total	417	7	1.68
χ^2		4.409	
p-value		0.049	

3.3. Occupational health risk assessment of excessive silica dust and chemical hazardous factors by year and enterprise size

Both silica dust and benzene have been classified as Level 4 occupational health risks, indicating a high degree of potential hazard and the need for stringent preventive and control measures. In contrast, the risks associated with manganese, xylene, and their compounds have been evaluated as Level 3, reflecting a moderate level of risk that nonetheless requires continuous monitoring and appropriate protective strategies to safeguard workers' health.

To provide a clearer understanding of the distribution and severity of these risks, the results of the occupational health risk assessment for excessive silica dust have been analyzed in detail. The data are presented according to year and enterprise size, enabling the identification of both temporal patterns and differences among large, medium, small, and micro enterprises. This stratification allows for a more nuanced interpretation of the findings, offering insights into how organizational scale may influence the degree of exposure, the adequacy of protective measures, and the overall effectiveness of occupational health management. The specific results of these assessments are summarized in **Tables 7 and 8**, which present the numerical data supporting this classification and highlight areas where improvements in occupational health practices are most urgently required.

Table 7. Occupational health risk assessment results of enterprises exceeding standards for silica dust exposure, categorized by year and enterprise size from 2019 to 2021

Year	Enterprise size	Number of enterprises exceeding standards (n)	HR	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	ER	R
2019	L	17	5	4	2	4		2	4		4	3	4
	M	7	5	4	3	2		2	3		3	3	4
	S	1	5	4	3	2		3	4		4	3	4
	Micro	5	5	5	4	3		3	4		3	3	4
2020	L	13	5	5	4	3		2	3		4	3	4
	M	5	5	4	3	3		4	4		3	3	4
	S	0	-	-	-	-		-	-		-	-	-
	Micro	2	5	4	3	3		4	3		4	3	4

Table 7 (Continued)

Year	Enterprise size	Number of enterprises exceeding standards (n)	HR	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	ER	R
2021	L	0	-	-	-	-		-	-		-	-	-
	M	0	-	-	-	-		-	-		-	-	-
	S	0	-	-	-	-		-	-		-	-	-
	Micro	1	5	4	3	3		2	2		3	3	4

Notes: (a) Engineering protective measures; (b) Occupational disease protective equipment; (c) Steam pressure/aerodynamic diameter; (d) Emergency rescue facilities; (e) Occupational health management; (f) Daily usage index; (g) Emergency rescue measures; (h) Daily exposure time index

Table 8. Occupational health risk assessment of enterprises exceeding permissible standards for chemical hazardous factors, presented by enterprise size and assessment year, including protective measures, management indicators, and exposure indices

Year	Enterprise scale	Number of Non-Compliant Enterprises (n)	Chemical Hazardous Factors	HR	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	ER
2019	L	17	Manganese & Compounds	3	2	3	-	3	2	-	4	3	3
	M	7	Manganese & Compounds	3	3	2	-	2	3	-	3	3	3
	S	1	Manganese & Compounds	3	3	2	-	3	3	-	4	3	4
	Micro	5	Manganese & Compounds	5	2	3	-	3	3	-	3	3	4
2020	L	13	Benzene	3	3	3	-	3	3	-	3	3	4
	M	5	Benzene	3	3	3	-	2	2	-	3	3	4
	S	0	Benzene	-	-	-	-	-	-	-	-	-	-
	Micro	2	Benzene	3	3	3	-	4	3	-	3	3	4
2021	L	0	Xylene	-	-	-	-	-	-	-	-	-	-
	M	0	Xylene	-	-	-	-	-	-	-	-	-	-
	S	0	Xylene	-	-	-	-	-	-	-	-	-	-
	Micro	1	Xylene	3	3	3	-	5	3	-	3	3	3

Notes: (a) Engineering control measures; (b) Occupational disease protective equipment; (c) Steam pressure/aerodynamic diameter; (d) Emergency rescue facilities; (e) Occupational health management; (f) Daily usage index; (g) Emergency rescue measures; (h) Daily exposure time index

3.4. Clarifying risk levels

After calculating the HR and ER values, specific factors classified as Level 4 include silica dust and benzene, identified as high-risk; Level 3 factors include toluene/manganese and their respective compounds, classified as medium-risk.

4. Discussion

The increasing harmfulness of occupational diseases is closely linked to the industrialization process in China. As the scale of industrial production expands, the variety of occupational diseases increases, and the scope of harm broadens [2]. Currently, occupational disease hazards are prevalent across multiple industries, including thermal power, manufacturing, and gas, posing a major threat to the physical and mental health of workers. Under these circumstances, comprehensive assessment of occupational disease hazards is a primary obligation for enterprises exposed to such risks. Regular evaluations of occupational disease hazards are necessary to develop effective protective measures and prevent various occupational diseases [3]. Occupational health risk assessment evaluates common hazardous factors in the workplace, targeting workers within those environments. It assesses the coverage and extent of hazardous factors, clarifies risk levels, identifies key points and challenges in occupational disease prevention, improves working conditions, and strives to eliminate hazardous factors. Occupational disease hazard factors and health risk assessments are primarily conducted by Centers for Disease Control and Prevention (CDCs). As the technical guidance center for health monitoring, inspection, and public health emergency response in Yangzhou City, the Yangzhou CDC places great importance on occupational disease prevention in the region [4]. Therefore, this study aggregates and analyzes data on occupational disease hazard factors in Yangzhou City from 2019 to 2021, while assessing occupational health risks to understand the level of emphasis placed on occupational disease prevention in Yangzhou and to formulate targeted subsequent management plans.

The results showed that the exceeding-limit rate for dust exposure operations conducted within three years was 1.71%, while the exceeding-limit rate for noise exposure operations was 4.42%. For operations involving chemical toxins, the exceeding-limit rate was relatively low, at only 1.68%. It is evident that the aforementioned factors are all common occupational hazards. The reason is that the pathogenic nature of dust and noise is often overlooked by various enterprises, as they do not lead to acute accidents and the cost of mitigation is high. Among dust hazards, silica dust is a high-risk factor for pneumoconiosis. During the manufacturing of refractory materials or glass products, the silica dust content is relatively high. Long-term exposure to silica dust can lead to abnormal electrocardiograms, directly affecting lung function and causing long-term impacts on the cardiopulmonary health of workers. Noise, which originates from processes such as cutting or machining, is mostly continuous steady-state noise characterized by mid-to-high frequency broadband noise. Noise severely affects the auditory system of workers and reduces nervous system function, leading to symptoms such as headaches or insomnia. According to the results in **Table 2, 3 and 4**, the exceeding-limit situations of occupational disease hazard factors significantly decreased in 2021. This is because various enterprises actively took corrective measures, paid high attention to potential hazard factors of occupational diseases, provided comprehensive training for staff, and improved the current rectification system, thereby reducing the exceeding-limit rate of hazard factors. In terms of the actual scale of enterprises, the highest exceeding-limit rate was observed in large enterprises, followed by medium/micro enterprises, with a $p < 0.05$.

Moreover, dust exceeding-limit was mainly distributed in large enterprises (7.45%), while noise exceeding-limit was mainly distributed in medium-sized enterprises (9.42%). The analysis suggests that large enterprises have dispersed production areas, a large number of workers, and complex management, requiring continuous substantial investment in the provision of dust prevention facilities and personal protective equipment. The persistence of prevention and control is poor, leading to higher difficulties in dust prevention. To prevent dust exceeding-limit, various enterprises need to increase supervision efforts based on their production scale and operational status. They can use educational and promotional means to enhance the occupational health awareness of workers, enabling them to conduct self-protection according to relevant standards. Wherever possible, closed pipelines should be used, and all processing operations should be completed within closed equipment to minimize the continuous escape of dust. If it is difficult to completely enclose the dust source, a semi-enclosed cover can be added or an isolation room can be set up to maximize the isolation of dust using hardware facilities, preventing workers from being exposed to large amounts of dust for extended periods and preventing its spread.

After medium-sized enterprises increase their production capacity but fail to promptly expand the production workshop area, the equipment layout becomes dense, resulting in noise superposition and significantly exceeding noise standards. To address this, the sound source can be controlled. Although it is difficult to completely control noise sources in traditional production processes, control can be exercised during the propagation of noise sources, such as by enhancing workers' awareness of protection through knowledge dissemination and skill training, enabling them to take effective self-protection measures.

Among the results, silica dust and benzene pose the highest risk levels (Level 4, high risk), followed by manganese, xylene, and their compounds (Level 3, medium risk). Therefore, various enterprises should attach great importance to the daily protection against harmful substances such as silica dust and benzene. They can conduct knowledge training to disseminate occupational health knowledge among workers, enabling them to master effective methods for preventing occupational diseases. Additionally, engineering control measures can be implemented to reduce workers' exposure to hazardous factors, thereby lowering exposure levels.

5. Conclusion

In summary, the main occupational hazards in Yangzhou City are dust, noise, benzene, xylene, and more, with silica dust and benzene posing high-risk levels. Corresponding measures need to be taken based on the above monitoring results to control risk factors and improve workers' physical health.

Disclosure statement

The authors declare no conflict of interest.

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