



Association Between Factory Workers' Profile with Chest X-ray Finding and Spirometry at Industrial Company of X

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Abstract

Background: Factory workers are a group at high risk of developing occupational lung abnormalities. Continuous exposure to dust, smoke, or gas particles during work processes may lead to progressive lung damage. Chest X-ray and spirometry are essential diagnostic tools for assessing both structural and functional lung changes, allowing early detection and prevention of occupational lung disability, especially among workers exposed to airborne pollutants.

Method: This analytical observational study employed a cross-sectional design to analyze the association between factory workers' profiles and chest X-ray and spirometry findings. Lung function was assessed using spirometry parameters, including Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV₁), and FEV₁/FVC ratio to identify restrictive or obstructive patterns. Data were collected using total sampling during periodic health examinations and analyzed with SPSS version 26.0. Descriptive statistics were used to summarize characteristics, while inferential analysis using Chi-square or Fisher's exact tests was conducted to determine associations between categorical variables, with a significance level set at P<0.05.

Results: A total of 260 factory workers participated, most with ≤5 years of work experience (60.76%). Comorbidities were significantly associated with both chest X-ray findings and lung function (P=0.034 and P=0.004). Smoking history and length of work also showed significant relationships with lung function (P=0.027 and P=0.019).

Conclusion: There is a significant association between smoking history and length of work with changes in lung function. Meanwhile, comorbidities have a significant association with lung structure and lung function. Periodic evaluation using spirometry and chest X-ray is essential for early detection and prevention of occupational lung abnormalities among factory workers.

Keywords: chest X-ray, factory workers, lung abnormalities, spirometry



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INTRODUCTION

Factory workers are at significant risk of encountering numerous health issues due to the conditions of their workplace environment. Overexposure to dust or smoke particles may result in lung damage and trigger occupational lung disease (OLD). Chronic obstructive pulmonary disease (COPD) creates a worldwide health issue that adversely affects the quality of workers. The International Labor Organization (ILO) cites about 250 million cases of COPD annually and 1.2 million deaths of workers resulting from accidents or OLD.^{1,2}

The prevalence of OLD in Indonesia is significant, although the existing data remains inadequate. The absence of comprehensive data regarding OLD complicates the diagnostic methodology for OLD. The conventional diagnostic technique is clinically challenging to differentiate due to several causes.² Occupational asthma is the most often diagnosed obstructive lung disease among workers. Moreover, many kinds of OLD may manifest both acutely and chronically, including hypersensitivity pneumonitis, COPD, and pulmonary fibrosis.^{2,3}

Dust particles supply a source of occupational exposure that leads to decreased lung function. Common exposures include coal mine dust, silica, fumes, vapors, gases, organic compounds, chemicals, metals, and infectious microorganisms. Long-term exposure

results in structural and physiological damage to the lungs.⁴

Spirometry tests and chest X-rays (CXR) can be used as measurements for the periodic evaluation of lung problems in workers. These problems are frequently correlated with additional characteristics, including age, gender, body mass index, and length of work.⁵

Several studies have shown that occupational exposure to dust, fumes, and industrial materials can cause structural and functional lung changes detectable through chest X-ray and spirometry. Such exposure may lead to radiological abnormalities like fibrosis or infiltrates and reduced spirometric values, including Forced Expiratory Volume in one second (FEV₁) and FEV₁/FVC ratio, as observed in occupational asthma and chronic obstructive patterns.⁶⁻⁸

This study is to examine the correlation between the profiles of manufacturing workers and the results of radiological exams and spirometry tests.

METHOD

This study employed an analytical observational design using a cross-sectional approach. Data collection was conducted by total sampling from October to November 2024, adjusted to the periodic health examination schedule of each work unit at PT X, Riau Province.

The inclusion criteria were factory workers who consented to participate and attended the health assessments, which included chest X-ray and spirometry

examinations. Workers who did not complete both examinations and were unable to perform the spirometry maneuver properly were excluded.

Spirometry examinations followed the standards of the American Thoracic Society (ATS) and the European Respiratory Society (ERS). Measurements were performed using a MIR SpiroLab® spirometer (Medical International Research, Rome, Italy), calibrated daily with a standardized volume device in accordance with ATS/ERS recommendations. Each participant performed at least three acceptable and reproducible maneuvers, and the best value was recorded.

Lung function was interpreted based on ATS/ERS reference criteria. Obstructive patterns were defined as an FEV₁/FVC ratio <0.70, and restrictive patterns as an FVC <80% of the predicted value with a normal or elevated FEV₁/FVC ratio. Predicted values were adjusted for age, sex, height, and ethnicity using the Global Lung Initiative (GLI 2012) reference equation. Potential confounding factors—including age, sex, body mass index (BMI), smoking history, comorbidities, and length of work—were controlled through stratified and subgroup analyses to minimize bias.

Data were analyzed using SPSS version 26.0 (IBM Corp., Chicago, IL, USA). Descriptive statistics summarized respondent characteristics. Normally distributed data were presented as mean±standard deviation (SD), while non-normal data were expressed as median. Bivariate analyses were conducted using

the Chi-square or Fisher's exact tests, and normality was verified with the Kolmogorov–Smirnov test. These tests were selected because the study variables were primarily categorical, aiming to identify associations between independent and dependent variables. A value of $P < 0.05$ was considered statistically significant.

Ethical approval was obtained from the Ethics Committee of the Faculty of Medicine, Universitas Riau, on October 18, 2024 (No. B/133/UN19.5.1.1.8/UEPKK/2024).

RESULT

This study collected 260 out of 300 plant workers who underwent periodic health assessments and satisfied the inclusion criteria between October and November 2024. The collected data comprised demographic information, including age, gender, body mass index, and smoking status, as well as comorbidities, length of work, radiological features, and spirometry tests.

Table 1 shows that factory workers were male (97.31%), with age >40 years (58.08%) being the highest group of factory workers in this study. Normoweight status (63.07%), no comorbidities (90.76%), and non-smoker (38.84%) were also the variables with the highest percentage in this study. Most of the factory workers had a length of work ≤5 years (60.76%).

Overall, based on the results of the spirometry test, 5 factory workers (1.91%) were found to have impaired lung function,

and 7 workers (2.67%) were observed to have structural lung abnormalities through chest X-rays.

Table 1. Distribution of Research Respondents

Characteristics	n	%
Age (mean±SD)	40.02±9.44	
≤40 years	109	41.92
>40 years	151	58.08
Gender		
Male	253	97.31
Female	7	2.69
Body Mass Index (BMI)		
Underweight	9	3.46
Normoweight	164	63.07
Obese 1	68	26.15
Obese 2	19	7.32
History of Smoking		
Non-smoker	101	38.84
Mild BBI	80	30.76
Moderate BI	55	21.15
Severe BI	24	9.25
Comorbidities		
No	236	90.76
Yes	24	9.24
Length of Work (mean±SD)	4.61±2.75	
≤5 years	158	60.76
>5 years	102	39.24
Chest X-rays		
Normal	253	97.33
Pleural Effusion	1	0.38
Infiltrates	1	0.38
Fibrosis	2	0.76
Fibroinfiltrates	3	1.15
Spirometry Tests		
Normal	255	98.09
Obstruction	1	0.38
Restriction	4	1.53

Table 2 shows that most factory workers obtained normal chest X-rays (97.33%), while 7 factory workers (2.67%) experienced abnormalities in the chest X-rays, consisting of pleural effusion, fibrosis, infiltrates, and fibroinfiltrates. The

comorbid factors had a significant association with abnormal chest X-rays ($P=0.034$). Abnormal chest X-rays were found in patients aged >40 years, male gender, underweight status, smoking history, and length of employment >5 years.

Table 3 shows that most factory workers obtained spirometry tests within normal limits at 98.09%. In addition, it was also explained that there were 5 workers (1.91%) who experienced impaired lung function with restriction and obstruction disorders. Pulmonary function disorders in this study were significantly associated with several factors, such as smoking history ($P=0.027$), comorbidities ($P=0.004$), and length of work ($P=0.019$).

Table 4 shows that there is no significant relationship between the findings on the chest X-ray and the results of the spirometry test ($P=0.932$). These results also explain that abnormal findings in chest X-rays do not impact those with lung function disorders. Conversely, lung function disorders, such as restriction and obstruction, were found with normal chest X-rays.

Table 4. Association of Chest X-ray Images with Lung Function in Factory Worker Profiles

Chest X-rays	Lung Function			P
	N	R	O	
Normal	249	4	1	0.932
Fibrosis	3	0	0	
Infiltrates	1	0	0	
Fibroinfiltrates	1	0	0	
Pleural Effusion	1	0	0	

Note: Fisher's exact test; $P<0.05$ statistically significant; N=Normal; R=Restriction; O=Obstruction

Table 2: Profile of Chest X-ray Features in Factory Workers

Variable	CXR Features					P
	Normal	Fibrosis	Infiltrates	Fibroinfiltrates	Pleural Effusion	
Age						
≤40 years	29	0	0	1	1	0.751
>40 years	224	2	1	2	0	
Gender						
Male	246	2	1	3	1	0.978
Female	7	0	0	0	0	
BMI						
Underweight	9	0	0	3	0	0.994
Normoweight	159	1	0	0	1	
Obese 1	66	1	1	0	0	
Obese 2	19	0	0	0	0	
History of Smoking						
Non-smoker	100	0	0	1	0	0.333
Mild BI	78	0	0	1	1	
Moderate BI	51	2	1	1	0	
Severe BI	24	0	0	0	0	
Comorbidities						
No	230	2	0	3	1	0.034*
Yes	23	0	1	0	0	
Length of Work						
≤5 years	142	1	0	1	0	0.866
>5 years	111	1	1	2	1	

Note: Chi-square test or Fisher's exact test as appropriate; statistically significant if P<0.05; BI=Brinkman Index; CXR=chest X-ray.

Table 3. Association of Factory Worker Profile with Lung Function

Variable	Lung Function			P
	Normal	Restriction	Obstruction	
Age				
≤40 years	105	3	1	0.198
>40 years	150	1	0	
Gender				
Male	248	4	1	0.932
Female	7	0	0	
BMI				
Underweight	9	0	0	0.644
Normoweight	161	2	1	
Obese 1	66	2	0	
Obese 2	19	0	0	
History of Smoking				
Non-smoker	101	0	0	0.027*
Mild BI	77	3	1	
Moderate BI	54	1	0	
Severe BI	24	0	0	
Comorbidities				
No	233	3	0	0.004*
Yes	22	1	1	
Length of Work				
≤5 years	158	0	0	0.019*
>5 years	97	4	1	

Note: Chi-square test or Fisher's exact test as appropriate; statistically significant if P<0.05; BI=Brinkman Index.

DISCUSSION

Factory workers are often faced with exposure or workloads that are hazardous to their health, so workers have the potential to experience health problems whose handling requires special efforts, especially when in the workplace and health service units. Work-related health problems are often incurable and cause disability and even death, so the main principle in providing health services for workers is to make prevention efforts as early as possible.^{6,7}

Factory X, a wood processing industry, is one of the industries that is developing rapidly at this time, with final products of paper and textile materials. Exposure risk factors obtained from the work environment are wood dust, cotton dust, and chemical exposure. Risks to the respiratory system are very likely to occur, so regular health checks are the main preventive measures to be taken.⁸

A spirometry test is recommended to assess lung function, and a chest X-ray is also the initial radiologic examination to evaluate potential lung abnormalities that may occur due to occupational exposure. Respiratory system disorders due to occupational exposure are known as OLD, which has a diagnosis that varies depending on the exposure that is often obtained.^{8,9}

This study analyzes several variables that are considered to have a direct or indirect association with structural and functional lung disorders obtained through spirometry and X-rays. The male gender

had the highest distribution in this study (97.31%), although this did not provide a statistical relationship to the results of chest X-rays and spirometry. The analysis related to this is not apart from the factor of higher smoking habits, so male tends to experience chronic lung diseases such as COPD, chronic bronchitis, and lung cancer.¹⁰

Proportionally, all male workers experienced both abnormalities of the lung structure (radiologically) and impaired lung function. Other studies conducted by Thepaksorn et al and Kargar-Shouroki et al also explained that male workers have a higher risk of lung function disorders due to the greater workload of male workers in work areas with high dust concentrations.^{2,11}

Most factory workers in this study were aged >40 years (58.08%). The age factor did not have a significant relationship with radiological and spirometric findings in this study. But proportionally, age >40 years impacts radiological abnormalities in the form of fibrosis, infiltrates, and fibroinfiltrates. This is the opposite of workers aged ≤40 years who tend to experience impaired lung function. Several studies mention that age has a relationship with decreased lung function. The age factor is related to the aging process, which causes an increase in a person's age to cause a decrease in lung function capacities.¹²

Kautsar and Sudarmaji reported a significant association between age and pulmonary function impairment ($P=0.001$), where workers aged over 40 years showed

a higher prevalence of reduced lung function. This supports the role of age-related physiological decline in increasing vulnerability to respiratory impairment among exposed workers.¹³

The nutritional status of workers was predominantly in the normoweight group (63.07%), followed by the grade 1 obesity group (26.15%). The BMI factor did not have a statistically significant relationship in this study. Nevertheless, proportionally, the normoweight group tends to impact those with lung function disorders. Meanwhile, the underweight group tends to cause structural changes radiologically, and the obese 1 group is more likely to have impaired lung function.

A study by Mauro et al explained that vital capacity (VC) can be affected by body weight. Physiologically, vital capacity will decrease along with obesity. The study also stated that normal weight and obesity conditions had significant differences. In addition, it is mentioned that the size of the neck circumference correlates with BMI and impacts a person's vital capacity.¹⁴

Smoking history can affect a person's lung capacity, so it can be used as a test variable in this study. The results of this study displayed that 38.84% of workers had no smoking history, and mild BI smoking status (30.76%) was the second highest percentage of all workers. The results showed a significant relationship between smoking status and the occurrence of lung function disorders, especially with mild BI smoking status ($P=0.027$).^{15,16}

The smoking habit will not only affect the level of oxygen exchange in the blood but will also be a potential factor for several lung diseases, including lung cancer. Smoking is four times more likely to cause structural and functional changes in the respiratory system and lung tissue than in non-smokers. This is why cigarette smoke exposure can affect lung function disorders.^{15,16}

Comorbidities can worsen the health conditions of factory workers who are at risk of daily exposure to the work environment. The results of this study showed that 90.76% of factory workers did not have comorbidities. However, this result was inversely proportional to the impact of comorbidities on radiological abnormalities and impaired lung function. The results of this study pointed out that workers who did not have comorbidities experienced fibrosis, fibroinfiltrates, and pleural effusion radiologically.^{17,18}

Based on a spirometry examination, it was found that factory workers experienced restriction disorders. Comorbid factors as test variables in this study have a significant relationship to radiological abnormalities ($P=0.034$) and impaired lung function ($P=0.004$). Comorbid status has a risk of susceptibility to recurrent infections, decreased endurance, and decreased lung capacity. This will very likely lead to the occurrence of COPD with occupational environmental exposure factors that are obtained every day.^{17,18}

Comorbidities were significantly associated with abnormal chest X-ray findings. Chronic illnesses such as diabetes mellitus, hypertension, or previous pulmonary infections can influence pulmonary structure through systemic inflammation, endothelial dysfunction, and decreased tissue repair capacity.¹⁷ These mechanisms may accelerate the development of radiologic abnormalities even in the absence of long-term occupational exposure. Workers with comorbid conditions are also more susceptible to recurrent infections and inflammatory responses that can contribute to interstitial changes or fibroinfiltrative patterns visible on chest X-rays.¹⁸

These findings suggest that the interaction between occupational exposure and individual health status determines the type of pulmonary abnormalities observed. Functional changes may develop earlier due to exposure-related airway reactivity, whereas structural abnormalities require prolonged exposure or the presence of underlying comorbid conditions to manifest radiologically.

The length of work is one of the main factors that determines the length of time a person is exposed to dust in the work environment, which can cause lung function problems.¹⁹ The longer the inhalation exposure, the greater the possibility of getting the risk, so one of the potential variables that can cause lung function disorders is the length of time a person is exposed to dust in the work environment.^{15,20} This study found that the length of work ≤ 5 years had a significant

relationship with impaired lung function ($P=0.019$).

In this study, the length of work was significantly associated with lung function impairment but had no significant relationship with chest X-ray findings. This may be explained by the relatively short average duration of employment (4.6 ± 2.7 years), which may not be sufficient to cause detectable radiological changes. Structural abnormalities on chest X-ray, such as fibrosis or infiltrates, generally occur after prolonged exposure exceeding 10 years, while functional impairment can appear earlier due to reversible airway inflammation or bronchial hyperreactivity.⁶⁻⁸

The results of this study concluded that radiological findings had no significant relationship to changes in lung function through spirometry results. But overall, the results of this study showed that there were 7 factory workers who had radiological lung abnormalities and 5 workers who had impaired lung function. These results indicate that comorbid factors have a statistically significant relationship to radiologic abnormalities and impaired lung function. Meanwhile, smoking status and length of work had a significant relationship only to changes in lung function.

In addition, the factory has implemented regular health monitoring and safety measures, including personal protective equipment (PPE) use and ventilation systems, which may have reduced cumulative exposure and prevented significant radiologic findings.⁹

This study has several limitations. Comorbidities such as congestive heart failure, COPD, asthma, and pulmonary tuberculosis could influence chest X-ray findings, particularly in relation to pleural effusion, but these factors were not adequately addressed. The assessment of exposure duration only accounted for the total number of years worked, neglecting daily or weekly working hours, which may lead to an underestimation of exposure intensity.

Additionally, the absence of data regarding PPE use and compliance could have obscured the connection between occupational exposure and lung abnormalities. Furthermore, educational background and occupational safety behavior, which might impact awareness and adherence to prevention measures, were not investigated. Future research should incorporate these variables to better differentiate between work-related and comorbidity-related findings and enhance causal inference regarding occupational lung disease.

CONCLUSION

The outcome profile of factory workers on chest X-rays and spirometry showed that comorbidities, smoking status, and length of work are significant risk factors for the potential occurrence of OLD. In addition, this can also be aggravated by age, gender, and BMI, although statistically, it does not show significance. The limitations of this study are expected to be improved by future studies with a

larger sample size, so that the homogeneous data can further strengthen the results of this study.

REFERENCES

1. Ambiya MZ, Novirianthy R, Andayani N, Mulia VD, Puspita NA. Hubungan lamanya paparan debu kayu dengan keluhan pernapasan pada pekerja kayu di Kota Banda Aceh. *Jurnal Kedokteran Syiah Kuala*. 2022;22(1):55–9.
2. Kargar-Shouroki F, Dehghan Banadkuki MR, Jambarsang S, Emami A. The association between wood dust exposure and respiratory disorders and oxidative stress among furniture workers. *Wien Klin Wochenschr*. 2022;134(13–14):529–37.
3. Gong X, Cui K, Liu Z, Tang Y, Li J, Chen Y, et al. The disease burden of pneumoconiosis in China from 1990 to 2021 and projection to 2050 based on GBD 2021: a cross-sectional study. *Front Public Health*. 2025;13:1583895.
4. Elfatih NM, Ali IA, Mohammed MA, Ahmed IA, Alaagib NA, Musa OA. Wood dust effects on carpenters pulmonary function test parameters: a comparative study. *BMC Pulm Med*. 2025;25:62.
5. Lestari M, Fujianti P, Novrikasari N, Nandini RF. Dust Exposure and Lung Function Disorders. *Respiratory Science*. 2023;3(3):218–30.
6. Dushyant K, Walia GK, Devasenapathy N. Lung Function and

- Respiratory Morbidity Among Informal Workers Exposed to Cement Dust: A Comparative Cross-Sectional Study. *Ann Glob Health*. 2023;89(1):47.
7. Jabur B, Ashuro Z, Abaya SW. Chronic respiratory symptoms and lung function parameters in large-scale wood factory workers in Addis Ababa, Ethiopia: a comparative cross-sectional study. *Int Arch Occup Environ Health*. 2022;95(6):1221–30.
 8. Awoke TY, Takele AK, Mekonnen WT, Abaya SW, Zele YT, Alemseged EA, et al. Assessment of dust exposure and chronic respiratory symptoms among workers in medium scale woodwork factories in Ethiopia; a cross sectional study. *BMC Public Health*. 2021;21(1):309.
 9. Ratanachina J, Amaral AFS, De Matteis S, Lawin H, Mortimer K, Obaseki DO, et al. Association of respiratory symptoms and lung function with occupation in the multinational Burden of Obstructive Lung Disease (BOLD) study. *European Respiratory Journal*. 2023;61(1):2200469.
 10. Dominelli PB, Molgat-Seon Y. Sex, gender and the pulmonary physiology of exercise. *European Respiratory Review*. 2022;31(163):210074.
 11. Thepaksorn P, Thongjerm S, Siriwong W, Ponprasit P. Occupational hazard exposures and health risks at wooden toys industry in Southern Thailand. *Human and Ecological Risk Assessment: An International Journal*. 2020;26(8):2162–72.
 12. Górski P, Białas AJ, Piotrowski WJ. Aging Lung: Molecular Drivers and Impact on Respiratory Diseases—A Narrative Clinical Review. *Antioxidants*. 2024;13(12):1480.
 13. Kautsar BM, Sudarmaji. Pulmonary Function Impairment Associated with PM_{2.5}, CO, and CO₂ Exposure in Home-Based Chips Industry Workers in Indonesia: A Cross-Sectional Study. *GEMA Lingkungan Kesehatan*. 2025;23(3):326–31.
 14. Lo Mauro A, Tringali G, Codecasa F, Abbruzzese L, Sartorio A, Aliverti A. Pulmonary and chest wall function in obese adults. *Sci Rep*. 2023;13(1):17753.
 15. Elshaer N, Foda N, Shehata S. Respiratory symptoms and pulmonary function impairment among textile industry workers in Alexandria, Egypt. *J Public Health Afr*. 2023;14(10):2741.
 16. Abateneh G, Gizaw Z, Gebrehiwot M, Worede EA. Prevalence of chronic respiratory symptoms and associated factors among woodwork workers in Bahir Dar City, Ethiopia; a comparative cross-sectional study. *BMC Pulm Med*. 2024;24(1):3.
 17. Whittaker H, Rubino A, Müllerová H, Morris T, Varghese P, Xu Y, et al. Frequency and Severity of Exacerbations of COPD Associated with Future Risk of Exacerbations and Mortality: A UK Routine Health Care Data Study. *Int J Chron Obstruct Pulmon Dis*. 2022;17:427–37.

18. Hadrup N, Sørli JB, Jenssen BM, Vogel U, Sharma AK. Toxicity and biokinetics following pulmonary exposure to aluminium (aluminum): A review. *Toxicology*. 2024;506:153874.
19. Kurniyanti N, Rahmawati, Kidingallo Y, Wiriansya EP, Selma R. Karakteristik Pasien Penyakit Paru Obstruktif Kronik di Rumah Sakit Ibnu Sina Makassar. *Fakumi Medical Journal: Jurnal Mahasiswa Kedokteran*. 2023;3(5):350–6.
20. Calaras D, David A, Vasarmidi E, Antoniou K, Corlateanu A. Hypersensitivity Pneumonitis: Challenges of a Complex Disease. *Can Respir J*. 2024;2024:4919951.