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Factors Related to Lung Function Disorders in Workers at The Printing Area of PT X

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Abstract: The use of chemicals in industry has benefits and negative impacts that follow. Solvent chemicals in the printing area of PT X are used to wash screen printing. One of the impacts of chemical use is the occurrence of impaired lung function in workers. The purpose of this study was to determine the factors associated with impaired lung function in workers in the printing area of PT X. This study is an observational study with a Cross Sectional approach. The population in this study was 84 workers in the printing area of PT X, with a total sample of 70 workers who have had a working period of more than 1 year. Data analysis was carried out by univariate and bivariate analysis using the Chi Square test. The results of this study indicate that there is a relationship between the habit of using PPE and impaired lung function in workers in the printing area of PT X (p value = 0.028), and shows no relationship between length of service (p value = 0.949), nutritional status (p value = 0.688), smoking intensity (p value = 0.967), exercise habits (p value = 0.957) with impaired lung function in workers in the printing area of PT X. Therefore, supervision through inspections and internal audits is needed in the implementation of occupational safety and health, especially in terms of the use of masks to prevent chemicals from entering the body.

Keywords: Impaired; Industry; Lung function; Solvent chemicals

Introduction

Industrial development is almost always a top priority in the development plans of developing countries (Mokoginta et al., 2024). However, on the other hand, industrial activities in their production processes are always accompanied by factors that pose a risk of occupational accidents and diseases (Fathurrahman & Jayanti, 2014). Chemicals such as heavy metals, pesticides, solvents, paints, detergents, kerosene, carbon monoxide, and drugs cause unintentional poisoning at home and in the workplace (Thristy et al., 2022).

According to the WHO, chemicals involved in unintentional occupational poisoning caused the deaths of 8,606 workers in 2019 (Aghaali et al., 2019). Data on occupational accidents and occupational diseases reported to the Ministry of Manpower through the Provincial Manpower Office for the 2019-2021 period indicate that occupational diseases caused by inhalation or absorption of hazardous materials or substances into the body, either through inhalation or through the skin, generally resulting in shortness of breath, suffocation, and other conditions, were 145, 109, and 101 cases, respectively (Kemenaker RI, 2022). Several factors influencing symptoms of impaired lung function include symptoms of impaired lung function due to chemical dust. Another factor that influences symptoms of impaired lung function is contact exposure (work period and length of exposure) (Sriwahyuningsih et al., 2020).

One of the manufacturing centers in Grobogan Regency, which produces bags, has a fairly complex production process. One of the processes involved is printing. PT X has 12,228 employees, divided into several departments: the main office, raw materials warehouse, cutting, printing, production (sewing),

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quality control, packaging, finished goods warehouse, and support departments such as maintenance. Annual production capacity reaches 16,869,543 bags, with an average monthly production of 1,405,795 bags.

The printing process at PT X is carried out both manually and using automated machines, with a total of 84 employees. In a single month, the printing process can produce 377,213 bags. The printing process involves numerous chemicals (Aydemir & Özsoy, 2020; Capel et al., 2018; Fink, 2014; Hartings & Ahmed, 2019). Printing at PT X is carried out for 8 hours per day, 5 days a week, using water-based paints to reduce the impact of chemicals on worker health and as a step towards product sustainability. The paint used in the printing process can reach 1,120 kg in one month. The screens used for printing are cleaned using organic solvents by hand washing in a dedicated screen printing washing area. The chemical used to wash screen printing is acetone (Khadayate et al., 2007). In one month, acetone usage can reach 420 liters. According to Agboola et al. (2025); Aljamali et al. (2022), the chemicals used in the screen washing process are irritating and carcinogenic, or cancer-causing.

In the modern industrial context, the use of hazardous chemicals has become commonplace to support various production and operational processes (Ali et al., 2005; Jenck et al., 2004). These chemicals are often necessary to improve efficiency, product quality, and technological innovation. However, despite their significant benefits, the use of these chemicals also carries significant health risks for exposed workers. Exposure to hazardous chemicals in the workplace can occur through various routes, including inhalation, skin contact, and accidental ingestion. Most of these chemicals have toxic properties that can have negative effects on human health. Repeated or long-term exposure to certain chemicals can cause serious health problems, such as respiratory diseases, neurological disorders, and cancer (Rahmadani & Syafri, 2024).

Method

This study used an observational cross-sectional approach, an epidemiological study in which variables are measured at a single point in time (Kim, 2023). The study was conducted in Grobogan Regency from July to August 2025. Supporting resources came from printing workers at PT X.

The population in this study was all 84 printing employees at PT X. The sample was drawn from a subset of the population using purposive sampling. Purposive sampling is the selection of research subjects based on certain characteristics or traits deemed closely related to the characteristics or traits of the population. In this study, 70 individuals were selected based on their willingness to participate and their work experience of more than one year. The independent variables in this study were length of service, nutritional status, PPE usage habits, smoking intensity, and exercise habits. The dependent variable was pulmonary function impairment among workers in the printing area of PT X. Data collection was conducted using a questionnaire administered to workers.

Univariate analysis was used to analyze a single variable presented in a frequency distribution table. The purpose of univariate analysis is to describe the characteristics of the data. Bivariate analysis is used to determine the existence of a relationship between the independent variable and the dependent variable using the Chi-Square test (Das et al., 2022; Msuha & Mdendemi, 2019).

Result and Discussion

Length of work

Length of service is a factor often associated with the risk of health problems due to workplace exposure, including respiratory disorders. The longer a person works, especially in a work environment that involves exposure to dust, chemicals, smoke, or other hazardous particles, the greater the chance of accumulated exposure, which can negatively impact lung function (Yasmeen & Hafeez, 2023). This condition can lead to decreased lung capacity, impaired ventilation, and even the development of occupational lung disease.

Lung disorders due to occupational exposure generally develop slowly and often go unnoticed in the early stages. Therefore, length of service is often used as an indicator of the duration of exposure to risk factors in the workplace. Several studies have shown that workers with longer tenure tend to have a higher risk of developing lung function disorders than workers with shorter tenure, although the extent of this risk can be influenced by the type of work, level of exposure, use of personal protective equipment, and individual health conditions.

Therefore, assessing the effect of length of service on lung disorders is crucial as a basis for efforts to prevent and control occupational health risks. Understanding the relationship between work period and impaired lung function is expected to provide an overview of the need for regular health monitoring, implementation of occupational safety and health, and control of environmental factors to protect workers' lung health.

Table 1 shows that of the 17 long-tenured workers, 3 (17.6%) experienced impaired lung function. Meanwhile, of the 53 new-tenured workers, 9 (17%)

experienced impaired lung function. The chi-square test yielded a p-value of 0.949, thus accepting H0 and rejecting Ha. Therefore, it can be concluded that there is no relationship between length of service and impaired lung function among workers in the printing area of PT.

Table 1. The results of analysis of the effect of work period on lung disease

Length of service	Positive		Negative		*p-Value*	RP (95% CI)
	frequency	Percentage %	frequency	Percentage %		
Long Working Period (*n*=17)	3	17.6	14	82.4	0.949	1.048
New Term of Work (*n*=53)	9	17	44	83		(0.294- 4.415)
Total	12	17.1	58	82.9		

To reduce the risk of impaired lung function among workers in the printing area, company owners can improve the workspace by installing ventilation and exhaust fans for air circulation to reduce chemical content in the work area. Providing personal protective equipment is essential to prevent exposure to chemicals.

Nutritional status

Nutritional status is a crucial factor in maintaining body function and endurance, including respiratory health (Shao et al., 2021; Wouters, 2021). Adequate nutritional intake affects respiratory muscle strength, lung function, and the immune system, which plays a role in protecting the lungs from infection and exposure to harmful substances. Poor nutritional status can lead to decreased immunity and weaken the lungs' physiological responses, increasing susceptibility to lung function disorders.

Lung disorders can be influenced by various factors, both internal and external. Nutritional status is an internal factor that contributes to the body's ability to adapt to occupational environmental exposures, such as dust, smoke, and chemicals. Individuals with poor or unbalanced nutritional status tend to have a higher risk of developing lung function disorders due to limited energy reserves and essential nutrients needed for tissue repair and optimal lung function.

Table 2. The effect of nutritional status on lung infections

Nutrition	Positive		Negative		*p-Value*	RP (95% CI)
	frequency	Percentage %	frequency	Percentage %		
Not good (*n*=20)	4	20	16	80	0.688	1.313
Good (*n*=50)	8	16	42	84		(0.347- 0.969)
Total	12	17.1	58	82.9		

Table 2 shown the 20 workers with poor nutritional status, 4 (20%) experienced impaired lung function. Meanwhile, of the 50 workers with good nutritional status, 8 (16%) experienced impaired lung function. The chi-square test yielded a p-value of 0.688, thus H0 was accepted and Ha was rejected. Therefore, it can be concluded that there is no relationship between nutritional status and impaired lung function in workers in the printing area of PT.

Nutritional status that falls into the overweight and obese categories places an additional burden on the thorax and abdomen, resulting in excessive stretching of the thoracic wall. This causes workers to fatigue easily and requires the respiratory muscles to work harder to generate high pressure in the pleural cavity to allow airflow during inspiration. Undernutrition can also indicate impaired lung function. This is caused by weakened respiratory muscles, which, although different from the restrictive mechanism, can still impair overall lung capacity (Harjono et al., 2025).

Personal protective equipment

The habit of using personal protective equipment (PPE) is a crucial step in preventing health problems caused by exposure in the workplace, particularly respiratory disorders (Buhler et al., 2025). PPE, such as masks or respirators, serves to reduce the amount of dust particles, fumes, and hazardous chemicals inhaled by workers. Failure to use PPE can increase the risk of hazardous materials entering the respiratory tract, potentially leading to impaired lung function.

Table 3. The effect of using personal equipment on lung infections

Habits of using PPE	Positive		Negative		*p-Value*	RP (95% CI)
	frequency	Percentage %	frequency	Percentage %		
Not using PPE (*n*=27)	8	29.6	19	70.4	0.028	4.105
Using PPE (*n*=43)	4	9.3	39	90.7		(1,097 - 15,361)
Total	12	17.1	58	82.9		

Table 3, show that of the 27 workers wearing PPE, 8 (29.6%) experienced impaired lung function. Meanwhile, 43 workers did not wear PPE, and 4 (9.3%) experienced impaired lung function. The chi-square test yielded a p-value of 0.028, thus rejecting H0 and accepting Ha. Therefore, it can be concluded that there is a relationship between PPE use habits and impaired lung function among workers in the printing area of PT X.

Simply put, PPE use is a set of tools worn by workers to protect part or all of their body from potential hazards or risks. PPE does not provide complete protection, but it can reduce the level of possible exposure. Suboptimal PPE use can be influenced by several factors, including incorrect selection of the appropriate type of PPE, improper use of PPE, using damaged PPE, and not replacing damaged PPE (Fahmi, 2012).

Smoking habit

Smoking is a major risk factor that can potentially affect lung function (Ramalho & Shah, 2021). Exposure to cigarette smoke, both active and passive, is known to cause short-term and long-term respiratory disorders. Different smoking intensities—ranging from light, moderate, to heavy—are thought to contribute to varying degrees to the development of lung dysfunction. Therefore, it is important to understand the distribution of lung dysfunction based on smoking intensity to understand the relationship between smoking habits and lung health. This table presents an overview of the distribution of respondents according to smoking intensity, the presence of lung dysfunction, and the results of statistical tests to assess the relationship between these two variables.

Based on Table 4, 7 workers who smoke heavily, 1 (14.3%) experienced impaired lung function. There was 1 worker with moderate smoking intensity, and 0 workers (0%) experienced impaired lung function. There were 17 workers with light smoking intensity, and 3 workers (17.6%) experienced impaired lung function. There were 45 non-smokers, and 8 workers (17.8%) experienced impaired lung function. The Chi-Square result obtained a p-value of 0.967, thus H0 was accepted and Ha was rejected. Therefore, it can be concluded that there is no relationship between smoking intensity and impaired lung function among workers in the printing area of PT X.

Table 4. The effect of smoking habit on lung infections

Smoking intensity	Positive		Negative		*p-Value*	RP (95% CI)
	frequency	Percentage %	frequency	Percentage %		
Weight (*n*=7)	1	14.3	6	85.7	0.967	a
Medium (*n*=1)	0	0	1	100		
Light (*n*=17)	3	17.6	14	82.4		
Not smoking (*n*=45)	8	17.8	37	82.2		
Total	12	17.1	58	82.9		

This is inconsistent with the existing theory that smoking can reduce lung function. This discrepancy may be caused by the researcher not considering other aspects such as the type of cigarette smoked, how the cigarette was smoked, and the duration of respondents' smoking intensity (heavy, moderate, light, and non-smokers). There were 21 workers who did not exercise, and 6 workers (12.2%) experienced impaired lung function. Meanwhile, there were 49 workers who exercised, and 6 workers (12.2%) experienced impaired lung function. The chi-square result obtained a p-value of 0.097, thus H0 was accepted and Ha was rejected. Therefore, it can be concluded that there is no relationship between exercise habits and impaired lung function in workers in the printing area of PT X.

Exercise habits

Workers in the printing area of PT X have a habit of doing aerobic exercise such as running, brisk walking, futsal, and volleyball. Regular exercise habits have an impact on increasing oxygen intake to the lungs, which can have many positive effects, such as improving work performance, lung function, and heart and blood vessel health (Afiani et al., 2016).

Table 5. The effect of excercise habit on lung infections

Exercise habits	Positive		Negative		*p-Value*	RP (95% CI)
	frequency	Percentage %	frequency	Percentage %		
Not habit (*n*=21)	6	28.6	15	71.4	0.097	2.867
Habitually (*n*=49)	6	12.2	43	87.8		(0.801 – 10.260)
otal	12	17.1	58	82.9		

Based on Table 5, the majority of workers (49) had a habit of exercising, while 21 did not exercise. Of the non-exercising workers, 6 (28.6%) experienced lung infections/impaired lung function, and 15 (71.4%) did not. Meanwhile, of the exercising workers, 6 (12.2%) also experienced lung infections/impaired lung function, while the majority (43) (87.8%) did not experience lung infections/impaired lung function.

The analysis showed a p-value of 0.097, indicating no statistically significant relationship between exercise habits and lung infections/impaired lung function in workers ($p > 0.05$). However, the Risk Prevalence (RP) value of 2.867 with a 95% confidence interval (0.801–10.260) indicates that workers without an exercise habit are approximately 2.9 times more likely to experience lung infections/impaired lung function than workers who exercise, although this relationship is not yet statistically significant.

Conclusion

Based on the analysis of the relationship between several risk factors and impaired lung function in workers, it can be concluded that the proportion of workers experiencing impaired lung function is 17.1%, while the majority of workers (82.9%) do not experience impaired lung function. The variable of length of service showed no significant relationship between length of service and impaired lung function ($p = 0.949$; RP = 1.048). This indicates that length of service does not significantly influence the occurrence of impaired lung function in workers. Nutritional status also showed no significant relationship with impaired lung function ($p = 0.688$; RP = 1.313). Although workers with poor nutritional status had a slightly higher percentage of impaired lung function, this difference was not statistically significant. Personal protective equipment (PPE) use was the only variable showing a significant relationship with impaired lung function ($p = 0.028$). Workers who did not use PPE had approximately a 4.1 times greater risk of developing lung function impairment than workers who did (RP = 4.105; 95% CI: 1.097–15.361). Smoking intensity did not show a significant association with lung function impairment ($p = 0.967$). The proportion of lung function impairment was relatively similar among light, moderate, heavy smokers, and nonsmokers. Exercise habits also did not show a statistically significant association with lung function impairment ($p = 0.097$), although workers who did not exercise tended to have a higher risk of developing lung function impairment than those who did (RP = 2.867). Overall, it can be concluded that PPE use is the most influential factor in the development of lung function impairment in workers, while work period, nutritional status, smoking intensity, and exercise habits did not show a statistically significant association in this study.

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Conflicts of Interest

The authors declare no conflict of interest.

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