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Factors Associated with Pulmonary Function Disorders Among Workers in the Printing Area of PT X

Rizqiana Fauziyyah*, Suhartono, Nurjazuli
Universitas Diponegoro, Indonesia
Email: rizqianafauziyyah@gmail.com*

ABSTRACT

Lung function disorders are among the occupational health problems frequently experienced by workers in industries exposed to chemicals, dust, and vapors generated during production processes. The printing area represents a work environment with a high potential for exposure to chemicals such as organic solvents (toluene, xylene, and formaldehyde), fine particulates, and combustion gases. The purpose of this study, Factors Associated with Pulmonary Function Disorders Among Workers in the Printing Area of PT X, is to identify and analyze factors related to impaired lung function among workers in the printing area based on a literature review. The method used is a systematic literature review involving article searches in the PubMed, ScienceDirect, ProQuest, and Google Scholar databases from 2013 to 2023. The synthesis results showed that work duration, exposure period, smoking habits, use of personal protective equipment, workspace ventilation, and concentrations of airborne chemicals were significantly associated with decreased pulmonary vital capacity (FVC) and first-second forced expiratory volume (FEV_1). Continuous risk management efforts, including routine spirometry examinations, worker education, and ventilation engineering, are essential to reduce the risk of lung disorders in the printing industry.

Keywords: *lung function, printing workers, chemical exposure, ventilation work, spirometry*

INTRODUCTION

The printing industry is one of the sectors at high risk of health problems due to exposure to chemicals and particulate matter in the air (Mohammadian & Nasirzadeh, 2021; Pongboonkhumlarp & Jinsart, 2022). The printing process uses various chemicals such as inks, organic solvents, and cleaning agents containing toluene, xylene, and formaldehyde, which are known to cause toxic effects on the respiratory system (Aydemir & Özsoy, 2020). According to Syamlal (2021) & Grahn (2021), about 15–20% of chronic obstructive pulmonary disease (COPD) cases in the working population are caused by workplace exposure. In Indonesia, data from the Ministry of Manpower show that cases of occupational diseases in the manufacturing industry increased by 12% during the 2018–2022 period, with lung function disorders being among the most common (Berlian et al., 2023; Vinnikov et al., 2023).

Lung function describes the ability of the respiratory system to deliver oxygen and expel carbon dioxide through the processes of ventilation and diffusion (Semchyk et al., 2021). The common parameters used are Forced Vital Capacity (FVC) and Forced Expiratory Volume in One Second (FEV_1) (Moon et al., 2021). Impaired lung function can occur due to chronic exposure to chemicals, dust particulates, and individual behaviors such as smoking or failure to use personal protective equipment (PPE) (Susanti, 2019).

Workers in PT X's printing area are exposed to various volatile chemicals that can cause airway inflammation, mucosal irritation, and a progressive decline in lung function (Ahmad & Balkhyour, 2020; Yasmeen & Hafeez, 2023). Long-term exposure also increases the risk of bronchial hyperreactivity and restrictive lung disease (Marchetti et al., 2023). Environmental factors such as air circulation, temperature, and humidity further exacerbate

these conditions (Weaver et al., 2022). This literature review aims to provide a scientific basis for efforts to prevent and improve working conditions in the printing industry (Abdelmeguid et al., 2022; bin Masod & Zakaria, 2024).

Previous research has highlighted various risk factors associated with impaired lung function in industrial settings (Wimalasena et al., 2021). A study by Kim et al. (2015) in South Korea identified a significant correlation between prolonged work duration and toluene exposure with decreased FEV_1 and FVC among printing workers. Similarly, Nugroho et al. (2018), in an Indonesian context, found that inadequate ventilation and smoking habits were associated with lung function decline. In contrast, a cohort study by Lin et al. (2017) in Taiwan focused on the impact of ozone and VOC exposure, reporting a higher incidence of respiratory symptoms and reduced pulmonary function. While these studies provide valuable insights, they often focus on isolated factors or specific geographical contexts. This study systematically integrates a multifactor analysis of chemical and behavioral exposures for the first time within Indonesia's printing industry context.

The objectives of this research on factors associated with pulmonary function disorders among workers in the printing area of PT X are to identify and analyze the key factors contributing to pulmonary function disorders among workers in the printing area of PT X through a systematic literature review. The benefits include providing evidence-based recommendations for occupational health interventions tailored to the printing industry. The implications of this study are expected to contribute to the development of comprehensive risk management strategies, including enhanced ventilation systems, stricter enforcement of personal protective equipment use, and regular health monitoring, ultimately reducing the incidence of work-related lung diseases and improving overall worker health and productivity.

METHOD

The research design was a systematic literature review. The literature search was conducted systematically to minimize publication bias. The databases used were PubMed, ScienceDirect, ProQuest, and Google Scholar. The search keywords included lung function, printing workers, respiratory disorders, occupational exposure, and spirometry.

The inclusion criteria were as follows:

1. Articles written in English or Indonesian.
2. Publications from 2013 to 2023.
3. Studies with an observational design (cross-sectional, cohort, or case-control).
4. Studies examining the relationship between exposure in the printing area and impaired lung function.

The exclusion criteria comprised non-systematic review articles, duplicate publications, and studies involving non-working populations in the printing industry.

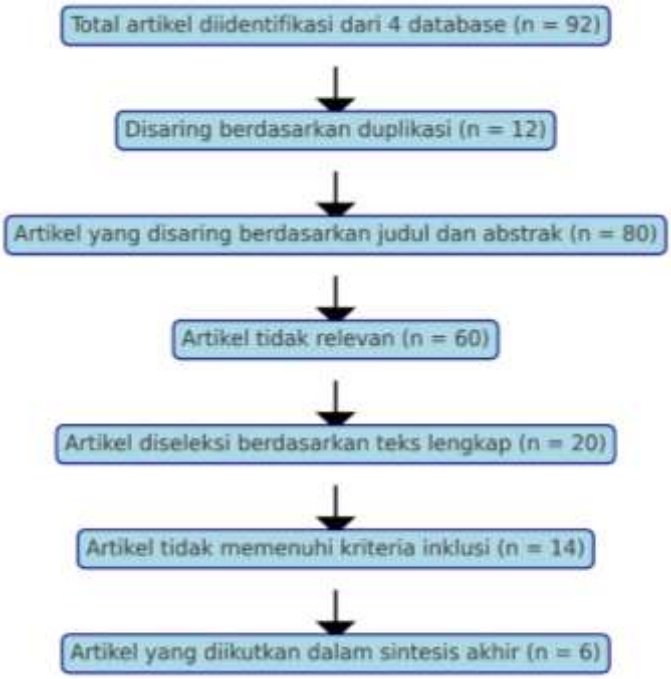

Figure 1. Article Search Flow
Source: Author's personal documents, 2024

RESULTS AND DISCUSSION

Table 1. Characteristics of Selected Articles

Author (Year)	Study Design	Location	Number of Samples	Variables Studied
Kim et al. (2015)	Cross-sectional	South Korea	150 employees	Working duration, FEV_1, FVC, toluene exposure
Nugroho et al. (2018)	Cross-sectional	Indonesia	82 printing workers	Length of work, smoking habits, ventilation
Lin et al. (2017)	Cohort	Taiwan	215 employees	Exposure to ozone gases and VOCs
Singh et al. (2019)	Case-control	India	120 workers vs control	Use of PPE and spirometry
Hassan et al. (2021)	Cross-sectional	Egypt	96 offset workers	Formaldehyde exposure, working period
Dewi et al. (2022)	Cross-sectional	Indonesia	65 employees	Duration of exposure, FEV_1/FVC value

Source: Data processed by the author, 2024

Table 2. Key Findings of Risk Factors for Impaired Lung Function in Printing Workers

Factor	Key Findings	Reference
Duration of work (>5 years)	Significantly related to a 10–15% decrease in FEV_1 and FVC compared to new workers	Kim et al., 2015; Dewi et al., 2022
Toluene/xylene/VOC exposure	Causes bronchial irritation and chronic inflammation of the airways	Lin et al., 2017
Poor ventilation	The concentration of solvent gases in the workspace exceeds NAV (Threshold Value) 2–3 times	Nugroho et al., 2018
Not using PPE	The risk of impaired lung function increased 2.4 times compared to workers who routinely wore respirator masks	Singh et al., 2019
Active smoking	The synergistic effect between cigarette smoke and organic solvents increases the risk of lung obstruction	Hassan et al., 2021

Source: Data processed by the author, 2024

The findings of this review align consistently with the Workplace Exposure and Lung Function Decline Model, which posits that chronic, low-level exposure to respiratory hazards in the work environment leads to cumulative damage and a progressive decline in pulmonary function. Exposure to chemicals in the printing process, such as toluene and formaldehyde, contributes to a significant decrease in lung function in workers primarily through mechanisms of oxidative stress and chronic bronchial inflammation, directly impacting FEV_1 values. The results of this review show that the longer the duration of work and exposure, the higher the risk of respiratory disorders, supporting the model's emphasis on exposure time as a critical factor.

In addition to chemical factors, individual behaviors such as smoking worsen lung conditions because they accelerate the damage to alveolar tissue and create a synergistic effect with occupational exposures, further accelerating functional decline. Environmental controls, such as ventilation, play a crucial role in this model by determining the intensity of exposure. Poor ventilation increases the concentration of solvents in the air, while the use of PPE has been shown to reduce the level of inhaled harmful substances by up to 70%, acting as a critical barrier between the hazard and the worker. These factors—environmental, temporal, and behavioral interact with each other in a multiplicative manner, influencing the trajectory of lung function decline.

Although data were derived from multiple countries with consistent findings, generalization to Indonesia's industrial context remains limited. Differences in regulatory enforcement, safety culture, climate conditions affecting ventilation, and the specific chemical mixtures used in local printing processes may alter risk profiles. Therefore, while the identified risk factors are universally relevant, their specific magnitude and interaction need validation through localized studies in Indonesia.

The scientific implication of this synthesis is the consolidation of scattered evidence into a coherent multi-factorial framework, reinforcing the applicability of the Workplace Exposure Model in the printing industry. Practically, these findings underscore the non-negotiable need for holistic prevention efforts. This must integrate robust risk management through engineering controls like ventilation improvement, administrative controls like worker education and rotation, and the strict enforcement of PPE usage, complemented by periodic spirometry checks to enable early detection and intervention.

CONCLUSION

Impaired lung function among printing area workers resulted from combined environmental and behavioral factors such as chemical exposure, long working duration, inadequate ventilation, and inconsistent use of personal protective equipment (PPE). A comprehensive prevention strategy should include improved ventilation systems, regular health monitoring, and ongoing PPE training to reduce respiratory health risks. Future research should explore the effectiveness of integrated intervention programs and evaluate long-term health outcomes among workers in various printing industry settings.

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