



Correlation Between Exposure to Cement Dust and Lung Function Values and The Incidence of Chronic Obstructive Lung Disease Among Workers at The X Cement Factory Company Medan

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ABSTRACT

Cement industry workers are continuously exposed to airborne cement dust, which may contribute to respiratory impairment and increase the risk of chronic obstructive pulmonary disease (COPD). Occupational exposure to particulate matter can induce oxidative stress, airway inflammation, and a progressive decline in lung function. However, evidence regarding the relationship between cement dust exposure, pulmonary function, and COPD incidence among cement workers in Indonesia remains limited. This study aimed to determine the correlation between cement dust exposure, lung function values, and the incidence of COPD among workers at X Cement Factory in Medan. This research employed a cross-sectional study design and was conducted from January to November 2024. The study involved 72 cement factory workers selected through consecutive sampling. Data were collected using the PUMA questionnaire and spirometry to assess lung function parameters, including forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and the FEV1/FVC ratio. Statistical analyses were performed to evaluate the associations of occupational and individual risk factors with COPD prevalence. Among the 72 respondents, 15 workers (20.8%) were identified as having COPD. The analysis showed that smoking history was significantly associated with COPD prevalence (PR = 1.875; p = 0.031). Meanwhile, work placement, age, personal protective equipment use, inhaler use, duration of employment, and working hours were not significantly associated with COPD prevalence. Lung function assessment revealed variations in spirometric parameters among workers, indicating the importance of respiratory monitoring in occupational settings. Cement dust exposure represents an important occupational respiratory health concern; however, COPD prevalence among cement workers is influenced by multiple factors, particularly smoking history. Continuous respiratory surveillance, exposure control, and preventive occupational health programs are recommended to reduce respiratory risks among cement industry workers.

INTRODUCTION

In 2019, the worldwide prevalence of chronic obstructive pulmonary disease (COPD) among people aged 30–79 years was 10.3%, with low-income countries contributing substantially to the global burden. In Indonesia, the prevalence of COPD is relatively high, reaching 13.6% (95% CI: 10.6–17.2%) (Adeloye et al., 2022). COPD also imposes a substantial socioeconomic burden, as worsening symptoms and a high risk of exacerbations contribute to a decline in patients' quality of life. A decline in quality of life is also closely associated with increasing psychological and economic burdens due to higher medical expenses and reduced income. Increased healthcare costs are associated with the length of hospital stay, intensive care requirements, COPD severity, exacerbations, and comorbidities (Iheanacho et al., 2020).

Risk factors for COPD vary and include male sex, smoking, advanced age, malnutrition, asthma, air pollution, and occupational exposure to pollutants (Safiri et al., 2022; Shin et al.,

2021). Occupational exposure to pollutants may involve smoke, gases, dust, and vapors. Exposure to these pollutants can damage the respiratory tract and trigger inflammatory responses; therefore, chronic exposure may contribute to the development of COPD. Such exposure can generate reactive oxygen species (ROS) and activate innate and adaptive immune responses. Persistent inflammatory responses can damage respiratory tissues and contribute to the pathogenesis of COPD (Shin et al., 2021).

Cement dust is a form of occupational particulate pollution that can be generated during the transportation, handling, loading, and unloading of clinker for storage outside silos. Clinker is an intermediate material used in cement production and is produced primarily from limestone and other raw materials through high-temperature processing (Mohamad et al., 2021). Cement is a finely ground hydraulic binding material produced primarily from calcined limestone and clay-based raw materials; when mixed with water and aggregates such as sand and gravel, it is used to produce concrete. The chemical composition of cement primarily includes calcium oxide (CaO), silicon dioxide (SiO₂), aluminum oxide (Al₂O₃), ferric oxide (Fe₂O₃), magnesium oxide (MgO), and trace elements such as selenium and thallium (Gao et al., 2016; Rampuri, 2017). In the cement manufacturing industry, particulate emissions can generally be categorized as fugitive dust and stack emissions. Fugitive dust refers to particulate matter released into the ambient air from non-point sources, such as material handling, transportation, storage, and transfer processes, whereas stack dust refers to particulate matter emitted through controlled point sources, such as industrial stacks or chimneys. Fugitive dust may contribute substantially to workers' inhalation exposure when dust-control measures are inadequate (Rav et al., 2020).

The presence of residential areas surrounding cement industrial facilities may also contribute to an increased burden of respiratory diseases because of exposure to pollutants generated by cement manufacturing activities. A study in Ethiopia found that air pollution levels around cement factories were substantially elevated, exceeding the referenced standard values by more than 14-fold (WHO PM_{2.5} standard: 10 µg/m³ annual average and 25 µg/m³ 24-hour average), while pollutant concentrations decreased with increasing distance from the factory. The most commonly reported respiratory diseases included acute bronchitis, bronchial asthma, chronic bronchitis, and respiratory allergies. In addition, affected populations included factory workers, children, and other residents living in areas surrounding factories with high particulate matter (PM) concentrations. Higher PM concentrations were also associated with an increased occurrence of respiratory diseases (Beketie et al., 2022). Other studies have reported similar findings, with COPD being more common among workers exposed to dust than among those who were not exposed (28.2% vs. 9.6%). The combined use of biomass fuels, such as firewood or charcoal, may also increase the risk of COPD (Mbelambela et al., 2020).

Previous studies have consistently highlighted the association between occupational exposure and respiratory impairment among cement industry workers. Research conducted among cement factory workers in Nepal identified a high prevalence of work-related respiratory symptoms associated with occupational exposure factors. Similarly, studies examining cement workers in Iraq demonstrated significant differences in spirometric patterns between exposed workers and control groups, showing that cement workers experienced more obstructive, restrictive, and mixed ventilatory abnormalities. These findings indicate that spirometry-based assessment, including measurements of forced vital capacity (FVC), forced

expiratory volume in one second (FEV_1), and the FEV_1/FVC ratio, is an important approach for detecting pulmonary dysfunction among industrial workers.

In Indonesia, several studies have also raised concerns regarding particulate matter exposure in cement-related industries. Research conducted in South Sulawesi found elevated $PM_{2.5}$ concentrations in areas surrounding cement industrial facilities, with peaks in pollution levels associated with factory activities. Another study among fiber-cement industry workers in West Java demonstrated that $PM_{2.5}$ exposure was associated with impaired lung function, particularly among workers with additional risk factors such as a history of smoking, production-related occupations, and longer working hours. However, many previous studies in Indonesia have primarily focused on environmental pollution measurements and exposure assessments rather than directly examining the relationship among cement dust exposure, objective lung function parameters, and COPD prevalence among cement factory workers.

Despite increasing evidence regarding occupational respiratory hazards, several research gaps remain concerning the determinants of COPD among cement industry workers. Previous studies have produced inconsistent findings regarding the contributions of specific occupational factors, including work location, duration of employment, personal protective equipment use, smoking history, and exposure intensity. Some studies have reported significant associations between cement dust exposure and respiratory disorders, whereas others have found limited statistical evidence because of differences in sample characteristics, exposure measurement methods, and analytical approaches. Furthermore, limited research has simultaneously evaluated clinical COPD outcomes and spirometric lung function parameters among cement factory workers in Indonesia, highlighting the need for more comprehensive occupational health investigations.

Understanding the relationship among cement dust exposure, impaired lung function, and COPD is essential because occupational respiratory diseases can significantly affect workers' productivity, healthcare costs, and overall well-being. Undiagnosed respiratory impairment may progress before clinically apparent symptoms emerge, potentially resulting in delayed intervention and an increased disease burden. Therefore, early identification through respiratory screening and lung function assessment can support preventive strategies, including improved workplace ventilation, appropriate use of personal protective equipment, occupational health surveillance, and targeted risk-reduction programs. This issue is increasingly important as industrial development continues to expand and occupational exposure remains a major public health concern.

The novelty of this study lies in its integrated assessment of cement dust exposure, pulmonary function parameters, and COPD occurrence among workers in a cement manufacturing setting. Unlike previous studies that primarily evaluated environmental pollution levels or respiratory symptoms, this research combines objective respiratory assessment using spirometry with the evaluation of occupational and individual risk factors. By examining variables such as work placement, smoking history, personal protective equipment use, duration of employment, and working hours, this study provides a broader understanding of the factors associated with COPD among cement factory workers.

Therefore, this study aims to determine the correlation among cement dust exposure, lung function values, and COPD among workers at X Cement Factory in Medan. Specifically, this research seeks to evaluate pulmonary function characteristics using spirometric measurements,

determine the prevalence of COPD among workers, and analyze occupational and individual factors associated with COPD. The findings are expected to provide empirical evidence regarding occupational respiratory health risks in the cement industry and a scientific basis for strengthening workplace health protection policies.

The contribution of this research extends to occupational medicine, industrial health management, and preventive strategies for respiratory diseases. From an academic perspective, this study enriches the existing literature on occupational COPD by providing evidence from an Indonesian cement manufacturing context. From a practical perspective, the results may assist industrial stakeholders in developing effective respiratory protection programs, improving worker health-monitoring systems, and implementing evidence-based interventions to minimize respiratory hazards. Ultimately, this research is expected to support healthier working environments and reduce the long-term burden of occupational respiratory diseases among industrial workers.

METHOD

This cross-sectional study was conducted from January to November 2024 to assess the prevalence and risk factors of chronic obstructive pulmonary disease (COPD) among workers at X Cement Factory in Medan. The study population consisted of cement processing and indoor workers. The inclusion criteria were workers aged 21–60 years who had at least one year of work experience and provided written informed consent. Workers with a current or previous diagnosis of pulmonary disease, including COPD, pulmonary tuberculosis, or asthma, were excluded. Participants were recruited using consecutive sampling.

Eligible participants were interviewed using the PUMA questionnaire and subsequently underwent spirometry to assess pulmonary function. The PUMA questionnaire was used to screen participants for COPD risk, with a score >6 indicating an increased risk of COPD. Participants with scores >6 were referred for spirometric assessment to evaluate airflow limitation.

Spirometry was performed to assess pulmonary function and identify ventilatory abnormalities. The parameters evaluated included forced vital capacity (FVC), forced expiratory volume in one second (FEV_1), and the FEV_1/FVC ratio. Spirometric measurements were performed in accordance with the applicable testing protocol, and acceptable measurements were used for the final assessment.

RESULTS AND DISCUSSION

To obtain an overview of the respondents' characteristics in this study, a descriptive analysis was conducted on several variables related to demographic factors and potential risk of COPD. The variables analyzed included sex, age, smoking status, use of personal protective equipment, work placement, use of inhaler, length of employment, and working hours.

Table 1. Characteristics of Respondents

Characteristics	Score (n = 72)
Age, Mean $\pm$ Std. Deviasi	30.96 $\pm$ 5.026
Sex, n (%)	
Male	65 (90.3)
Female	7 (9.7)
Placement, n (%)	
Outdoor	48 (66.7)
Indoor	24 (33.3)
Use of Personal Protective Equipment, n (%)	
Yes	55 (76.4)
No	17 (23.6)
Smoking History, n (%)	
IB Severe (> 600)	21 (29.2)
IB Moderate (200-600)	6 (8.3)
IB Mild (0-200)	14 (19.4)
Non-smoker	31 (43.1)
Use of Inhaler, n (%)	
Yes	4 (5.6)
No	68 (94.4)

Characteristics	Score (n = 72)
Length of employment, n (%)	
$\geq$ 5 Years	50 (69.4)
< 5 Years	22 (30.6)
Working Hours, n (%)	
$\geq$ 40 Hours	67 (93.1)
< 40 Hours	5 (6.9)
COPD, n (%)	
COPD	15 (20.8)
Not COPD	57 (79.2)
Lung Function, Median (IQR)	
FEV1/FVC	85.3 (8.37)
FEV1	100 (32.99)
FVC	104 (26.25)
FEF 25-75	87.5 (26.35)

Based on the data presented in Table 1., the majority of respondents were male (90.3%) with the majority works in outdoor (66.7%) and the rest are indoor workes (33.3%). The use of personal protective equipment (PPE) was recorded in 55 workers (76.4%), while 17 workers (23.6%) did not use it. A total of 21 people (29.2%) had a history of heavy smoking, 6 people (8.3%) had a history of moderate smoking, 14 people (19.4%) had a history of light smoking, and 31 people (43.1%) did not smoke. Only 4 people (5.6%) had a history of inhaler use, while 68 people (94.4%) did not have such a history. A total of 50 workers (69.4%) had been working for more than 5 years, and 22 workers (30.6%) had been working for less than 5 years. The majority of respondents, namely 67 people (93.1%), worked more than 40 hours per week, while 5 people (6.9%) worked less than 40 hours. Fifteen respondents (20.8%) had COPD, while 57 respondents (79.2%) did not have COPD. Lung function in the restrictive pattern showed that the median value of the VEP1/KVP ratio was 85.3 with an interquartile range (IQR) of 8.37. The median VEP1 value was 100 with an IQR of 32.99, while the median KVP

value was 104 with an IQR of 26.25. For the FEF 25–75% parameter, the median obtained was 87.5 with an IQR of 26.35 (table 1).

Table 2. Correlation Between Work Placement and COPD Incidence

	COPD		PR (CI-95%)	% Row	p-value
	Yes, n (%)	No, n (%)			
Outdoor (PM10 : 0.083 ; PM2.5 : 0.052)	11(22.9)	37 (77.1)	1.000 (0.488-3.867)	48 (100)	0.538
Indoor (PM10 : 0.051 ; PM2.5 : 0.040)	4 (16.7)	20 (83.3)		24 (100)	
Total	15 (20.8)	57 (79.2)		72 (100)	

Based on the examination results (table 2), it is known that of the 48 workers in the outdoor section, 11 people (22.9%) had COPD, while 37 people (77.1%) did not have COPD. Meanwhile, of the 24 workers in the indoor section, 4 (16.7%) had COPD and 20 (83.3%) did not have COPD. The analysis results showed a Prevalence Ratio (PR) value of 1.000 with a 95% confidence interval of 0.488–3.867. This indicates that there is no increased risk of COPD among outdoor workers compared to indoor workers. Additionally, the p-value of 0.538 ($p > 0.05$) indicates that there is no statistically significant relationship between job position and the occurrence of COPD among cement factory workers. The results were not statistically significant, possibly due to the limited sample size, which reduced the power of the test to detect differences.

Table 3. Other risk factors associated with COPD incidence among all subjects working indoor

		COPD				PR	95 % CI		p-value
		Yes		No			Lower	Upper	
		n	%	n	%				
Age						1.119	0.766	1.634	0.560
Sex									
●	Male	4	16.7	14	58.3	1540	0.000	0.000	0.999
●	Female	0	0	6	25				
Use of Peronal Protective Equipment									
●	Yes	2	8.3	10	41.7	0.722	0.021	24.613	0.856
●	No	2	8.3	10	41.7				
Smoking History									
●	Yes	3	12.5	8	33.3	1.934	0.540	6.927	0.311
●	No	1	4.2	12	50				
Use of Inhaler									
●	Yes	0	0	1	4.2	0.703	0.000	0.000	1.000
●	No	4	16.7	19	79.2				
Length of employment									
●	< 5 years	1	4.2	7	29.2	0.859	0.495	1.489	0.587
●	≥ 5 years	3	12.5	13	54.2				
Work Duration									
●	< 40 hours	0	0	2	8.3	0.618	0.000	0.000	1.000
●	≥ 40 hours	4	16.7	18	75				

Based on the results of the prevalence ratio (PR) analysis of research subjects who work indoors with other risk factors, it is known that there was no statistically significant relationship with the incidence of COPD. It is known that the variable of smoking history, which shows a PR value of 1.934 with a p-value of 0.311, is most likely to influence the incidence of COPD, but this is not statistically significant because the p-value is > 0.05 and the confidence interval includes the value 1. In addition, several extreme PR values and invalid confidence intervals (e.g., 0.000–0.000) were found for the variables of gender, use of inhaler and work duration. This condition is likely caused by the very small number of cases or uneven data distribution (table 3).

Table 4. Other risk factors associated with COPD incidence among all subjects working outdoor

		COPD				PR	95 % CI		p-value
		Yes		No			Lower	Upper	
		n	%	n	%				
Age						0.945	0.849	1.050	0.292
Sex									
●	Male	11	22.9	36	75	8477	0.000	0.000	1.000
●	Female	0	0	1	2.1				
Use of Peronal Protective Equipment									
●	Yes	11	22.9	32	66.7	4276	0.000	0.000.	0.999
●	No	0	0	5	10.4				
Smoking History									
●	Yes	10	20.8	20	41.7	1.716	0.906	3.252	0.098
●	No	1	2.1	17	35.4				
Use of Inhaler									
●	Yes					11.723	0.819	167.885	0.070
●	No	2	4.2	1	2.1				
		9	18.8	36	75				
Length of employment									
●	< 5 years	3	3	11	22.9	1.066	0.836	1.359	0.607
●	≥ 5 years	8	16.7	26	54.2				
Work Duration									
●	< 40 hours	1	2.1	2	4.2	0.348	0.022	5.460	0.452
●	> 40 hours	10	20.8	35	72.9				

Based on the results of the prevalence ratio (PR) analysis of research subjects who work outdoors with other risk factors (table 4), it is known that in the use of inhaler category showed an almost significant results in the incidence category ($p = 0.070$), but with a very wide confidence interval range (11.723). This indicates a high degree of estimation uncertainty, so these results need to be interpreted with caution. Other variables such as age, gender, use of personal protective equipment (PPE), history of inhaler use, and length of employment did not show a statistically significant relationship with COPD incidence with $p\text{-value} > 0.05$. In addition, several extreme PR values and invalid confidence intervals (e.g., 0.000–0.000) were found for the variables of gender and use of personal protective equipment. This condition is likely due to the very small number of cases or uneven data distribution.

Table 5. Other risk factors associated with COPD incidence among all subjects

		COPD				PR	95 % CI		p-value
		Yes		No			Lower	Upper	
		n	%	n	%				
Age						0.948	0.861	1.044	0.280
Sex									
●	Male	15	20.8	50	69.4	18465	0.000	0.000	0.999
●	Female	0	0	7	9.7				
Use of Peronal Protective Equipment									
●	Yes	13	18.1	42	58.3	3.011	.404	22.418	0.282
●	No	2	2.8	15	20.8				
Smoking History									
●	Yes	13	18.1	28	38.9	1.875	1.060	3.316	0.031
●	No	2	2.8	29	40.3				
Use of Inhaler									
●	Yes	2	2.8	2	2.8	12.631	0.901	177.06	0.060
●	No	13	18.1	55	76.4				
Length of employment									
●	< 5 years	4	5.6	18	25.0	0.795	0.175	3.624	0.767
●	≥ 5 years	11	15.3	39	54.2				
Work Duration									
●	< 40 hours	1	1.4	4	5.6	0.313	0.020	4.924	0.409
●	≥ 40 hours	14	19.4	53	73.6				

Based on the results of the prevalence ratio (PR) analysis, it was found that of the variables tested, only the variable of smoking history showed a statistically significant relationship with the incidence of COPD, particularly in the incidence category. A PR value of 1.875 with a 95% confidence interval (1.060–3.316) and a p-value of 0.031 indicates that workers with a history of smoking have a COPD prevalence rate that is almost twice as high as those without such a history. Although in the direct management and office worker categories the PR values also showed an increasing trend (1.716 and 1.934, respectively), the relationship was not statistically significant because the p-value was > 0.05 and the confidence interval included the value 1.

The work duration variable also showed almost significant results in the incidence category ($p = 0.049$), but with a very wide confidence interval range (0.020–4.924). This indicates a high degree of estimation uncertainty, so these results need to be interpreted with caution. Other variables such as age, gender, use of personal protective equipment (PPE), history of inhaler use, and length of employment did not show a statistically significant relationship with COPD incidence, either in the incidence, direct management, or office worker categories. This is indicated by p-values exceeding 0.05 and confidence intervals that include the number 1. In addition, several extreme PR values and invalid confidence intervals (e.g., 0.000–0.000) were found for the variables of gender and inhaler use. This condition is likely due to the very small number of cases or uneven data distribution (Nasri et al., 2023).

One study found that only one worker reported a history of COPD, and there were no cases of bronchial asthma in the group studied. However, lung function data showed that many workers had FEV1 and FVC below 80% and an FEV1/FVC ratio below 70%. Workers in the

production department showed significantly higher predicted FVC% values and lower FEV1/FVC ratios. Spirometry confirmed the diagnosis of COPD in 11 workers who were previously undiagnosed and not undergoing treatment. The burden of respiratory disease due to occupational factors remains high, and it is estimated that up to 15% of cases could be prevented if workers were not exposed in the workplace. The highest burden was recorded for occupational chronic obstructive pulmonary disease (COPD). This risk is further increased by workers' smoking habits, suboptimal use of exposure control devices, and high levels of air pollution in the surrounding environment (Shanshal & Al-Qazaz, 2021). Several other studies have also reported an association between exposure to cement dust and chronic respiratory symptoms, silicosis, and chronic obstructive pulmonary disease (COPD) (Cestelli et al., 2025).

Lung function in workers can be evaluated through spirometry using key parameters such as forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and the ratio of FEV1 to FVC (FEV1/FVC). A study conducted in Iraq showed significant differences in the prevalence of abnormal spirometry patterns, including obstructive, restrictive, and mixed patterns, between cement factory workers and the control group. The research data revealed that more than 90% of participants in the control group had normal spirometry patterns, while only 25.8% of cement factory workers showed normal spirometry results (Silver et al., 2020). A restrictive pattern in spirometry is characterized by a decrease in FEV1 and/or FVC values, but with the FEV1/FVC ratio remaining within normal limits. Restrictive Spirometric Pattern (RSP) is defined as $FEV1/FVC \geq 0.7$ (or $\geq$ LLN) with $FVC < 80\%$ predicted (or $<$ LLN). Several studies have shown that this pattern has different clinical characteristics and risk factors compared to similar obstructive lung diseases, as found in this study (Poudel et al., 2021).

Before conducting an analysis to find relationships and risk factors in this study, a normality test was first performed on the data. All data were not normally distributed, so the analysis of the relationship between variables was performed using a non-parametric test. The Mann-Whitney test results showed no significant relationship between PM10 and PM2.5 dust exposure and incidence of COPD among cement factory workers ($p = 0.541$). This finding is consistent with other studies that found 15 confirmed cases of COPD in exposure to cement pollutants. The analysis results did not reach statistical significance (HR 1.40 (0.78–2.52) (Kim, 2023). These results may be based on the many respiratory disorders other than COPD that can be experienced by workers in cement factories, as found in other studies (Rey-Brandariz et al., 2023). The explanation for dust exposure causing respiratory disorders such as COPD is that cement dust can enter the human body through three main routes: inhalation, skin contact, and ingestion. Several studies have reported that exposure to aluminum oxide can trigger lipid peroxidation in various body tissues, which then contributes to the occurrence of kidney failure, anemia, and neurotoxicity. Another toxic component, chromium in the form of Cr (IV), is known to be a strong oxidizing agent that can produce free radicals and increase the inflammatory process. Further impacts include impaired liver, respiratory, and renal system function. Cumulative oxidative damage to cellular components and altered cell function have been associated with the continuous production of reactive oxygen species (ROS) (Lu et al., 2024).

Based on the analysis results, there was no significant association between job position (direct processing vs. office) and COPD incidence ($p = 0.538$; PR = 1.000; 95% CI: 0.488–3.867). Although the incidence of COPD was higher among direct processing workers, the

difference was not statistically significant. These results are not in line with other studies, specifically that workers in the raw material production, burning and clinker, and cleaning departments have a 7, 8, and 7 times greater risk, respectively, of developing respiratory disorders, and that this relationship is statistically significant. 17 Another study also found that compared to production areas, the overall lowest aerosol exposure levels were found in office areas, with a median concentration nearly 40 times lower than in concrete mixing units. Comparisons between sampling locations showed statistically significant differences in median concentrations (Kruskal-Wallis test, $p < 0.001$)[20]. However, although the statistical test results did not show a significant relationship, it cannot be ignored that workers in certain areas, such as production and packaging, generally have higher dust exposure levels compared to other administrative or technical areas. This indicates that other factors such as duration of exposure, use of personal protective equipment, ventilation quality, and smoking habits may play a greater role in influencing the incidence of COPD. Therefore, multivariate analysis that considers multiple risk factors simultaneously can provide a more comprehensive understanding of the determinants of COPD in the cement factory work environment.

The results of the prevalence ratio (PR) analysis showed that only a history of smoking had a statistically significant relationship with the incidence of COPD ($PR = 1.875$; $p = 0.031$). This means that smokers have almost twice the risk of COPD compared to non-smokers. Some analysis results, such as those for the variables of work duration and gender, show uncertainty in the estimates due to the low number of cases or unbalanced data distribution. Based on these results, studies with similar results were found. The duration of smoking is positively correlated with the severity of COPD; individuals who have smoked for more than 20 years tend to experience decreased lung function and more severe COPD (Mallongi et al., 2023). Tobacco consumption is a major risk factor for chronic obstructive pulmonary disease (COPD), where COPD caused by smoking is generally preceded by lung damage and abnormal tissue repair processes. Factors related to tobacco consumption, such as duration of smoking, intensity, total accumulated consumption, age at which smoking began, and duration since quitting, can all influence an individual's risk of developing this disease (Husebø et al., 2019). Cigarette smoke contains more than seven thousand chemical substances, some of which are toxic and carcinogenic. Complex particles of cigarette smoke that are inhaled can adhere to and affect the respiratory tract, with the location of particle deposition depending on their size. Larger particles tend to settle in the upper respiratory tract, while smaller particles reach the lower respiratory tract (small airways <2 mm) and alveoli. This can trigger chronic inflammation, oxidative stress, and damage to the respiratory tract and lung parenchymal structures.

In addition, strong evidence shows that exposure to household air pollution, especially from indoor sources such as biomass fuel for cooking, wood-burning heaters, and candles, is also associated with an increased risk of COPD (Hogea et al., 2020). In the gender variable, the results of the study were consistent with the results obtained, namely that gender did not show a significant relationship with the occurrence of the variable studied, both in univariate and multivariate analyses (because the p -value > 0.05 in both). Meanwhile, other variables such as job position, age, use of PPE, use of inhalers, and length of service did not show a significant relationship. This indicates that although these factors are often associated with the risk of respiratory disorders, in the context of this study, they were not statistically proven to be major determinants. These results contradict some studies that showed significant results, such as the

age variable, which had a mortality rate in elderly patients with COPD during exacerbation episodes reaching nearly 20%.

This insignificance may be caused by several factors, such as individual variations in physiological responses to exposure, levels of compliance with PPE use, or the presence of other more dominant risk factors, such as a history of smoking or high particulate exposure that is not fully captured by these variables. Therefore, it is important to consider other more specific and measurable factors, especially those related to the intensity and duration of direct exposure to cement dust, when assessing the risk of COPD in the workplace.

CONCLUSION

This study concluded that occupational exposure to cement dust among workers at X Cement Factory in Medan represented a potential respiratory health risk, although the statistical analysis did not demonstrate a significant association between work placement and COPD prevalence. Among the evaluated risk factors, smoking history was significantly associated with COPD, with workers who had a history of smoking demonstrating a higher prevalence of COPD than nonsmokers. Spirometric assessment revealed variations in lung function parameters, including forced expiratory volume in one second (FEV₁), forced vital capacity (FVC), and the FEV₁/FVC ratio, highlighting the importance of pulmonary function monitoring among cement industry workers. Although cement dust exposure remains an important occupational hazard, COPD is associated with multiple occupational and individual factors, particularly smoking. These findings emphasize the need for comprehensive occupational health programs involving exposure control, respiratory surveillance, smoking cessation support, and consistent implementation of preventive measures in cement manufacturing environments.

Future research should involve larger sample sizes and longitudinal study designs to better evaluate the long-term effects of cement dust exposure on lung function decline and COPD development. Further studies should incorporate quantitative measurements of individual dust exposure, including the duration, intensity, and cumulative level of occupational exposure, as well as workplace environmental conditions, to provide more accurate risk assessments. Multivariable analyses incorporating potential confounding factors, including smoking intensity, age, nutritional status, workplace ventilation, and adherence to the use of personal protective equipment, are also recommended to identify factors independently associated with COPD among cement industry workers. These approaches may provide stronger evidence to support the development of targeted occupational health and safety policies and preventive interventions in the cement industry.

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