



Association between Air Pollution in Industrial Areas and Respiratory Diseases : A Literature Review

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Abstract

Air pollution is an environmental problem that has a major impact on human health. Air pollutants that enter the respiratory tract can promote oxygen reactions, trigger immune response irregularities, cause oxidative stress, and eventually lead to lung inflammation. Industry, as one of the largest sources of pollutants, can release pollutants that affect the lung health of workers and also the surrounding communities living around the industry. This article aims to discuss

the relationship between air pollution and respiratory problems experienced by communities around industries or industrial workers. This article was compiled using the literature review method using research articles, sourced from PubMed, Science Direct and Google Scholar in the 2019-2024 timeframe, and obtained 10 articles that were discussed further. The results of the literature review show that distance from the source area of exposure to air pollutants has a significant relationship to the occurrence of respiratory disorders. People exposed to air pollutants are more at risk of death from respiratory problems, especially infants and the elderly. Air pollutants also play a role in reducing the expiratory volume in the first second (FEV1) of the lungs. Industries are expected to be able to manage the risk of air pollution in order to minimize the impact caused to the surrounding industry.

Keywords: : *air pollution, industry, respiratory diseases*

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Introduction

Air pollution is generated by vehicles, industries, and commercial operations. Kind of air pollutants include Particulate Matter (PM), carbon monoxide (CO), nitrogen dioxide (NO₂), sulfur dioxide (SO₂), and ozone or oxygen triplet (O₃). Particulate Matter can be sourced from dust on construction sites, industrial sources, waste incineration (California Air Resources Board, 2024). CO is derived from vehicle exhaust fumes and power, while NO₂ is derived from fossil fuel combustion of power plants, motor vehicles, and industries (Saxena et al., 2019). SO₂ is derived from fossil fuel combustion (transportation, coal power plants, and oil refineries) (Crume, 2018) while O₃ is derived from the reaction of oxygen in the air triggered by a decrease in the concentration of carbon aerosols in ambient air (Zhang, Wei and Fang, 2019).

Air pollutants are potential in creating serious impacts on human health. There are approximately 6.7-7 million deaths associated to air pollution per year (Our World In Data, 2021). Deaths associated with outdoor air pollution factors occur as much as 37% occur due to ischemic heart disease and stroke, 18% occur due to chronic lung disease, 23% occur due to lower acute respiratory infections, while 11% occur due to respiratory cancer. By 2019, each year, air pollution can cause 4.2 million premature deaths. (World Health Organization, 2022). Air pollution-related deaths can occur due to exposure to fine particulates (PM). PM₁₀ and PM_{2.5} can enter the respiratory tract, especially the lungs, and enter the circulatory system, increasing the risk of respiratory and heart disease (World Health Organization, 2018).



Air pollutants inhaled by humans can encourage oxygen reactions and can trigger immune system disorders. Irregularities in the immune response can affect the occurrence of respiratory epithelial oxidative stress which can increase the susceptibility of viral infections that have attacked the respiratory system (Endaryanto et al., 2023). Oxidative stress can lead to inflammation in the lungs. This can trigger respiratory infections, such as asthma, chronic obstructive pulmonary disease, and lung cancer (Loaiza-Ceballos et al., 2022).

Industries can contribute much to air pollution. Industrial activities can release several pollutants that can pollute the air. For example, the paint industry can produce heavy metals such as cadmium and lead that can trigger lung cancer. Another example is dust in the textile industry, which can lead to respiratory diseases (Mohammadi et al., 2022). Pollutants produced by industry can affect the lung health of workers and also the surrounding community living around the industry. If air pollution is high, workers and the surrounding community will be more at risk of respiratory infections and even lung cancer.

This article aims to discuss the association between air pollution in industrial areas and respiratory problems experienced by the surrounding community who live near industrial areas, as well as workers in the industry.

Methods

This article was structured using the literature review method. The articles used were research articles, sourced from PubMed, Science Direct and Google Scholar. The search keywords were “air pollution AND industry AND respiratory infection” on PubMed and Science Direct and



“air pollution industry respiratory” on Google Scholar. From the search results, 25 article titles were collected that met the search criteria, then elimination was carried out if the article could not be downloaded in full text, so that 10 articles could be downloaded and met the search criteria. The time range of the article search is the last five years (2019-2024).

Results

Here is the result of collected articles as follows on the table.

Table 1. Literature Review Result

No	Author and Publication Year	Title	Methods	Results
1	(Farihah Mohmad Shamsuddin et al., 2022)	Exposure to industrial air pollution and its association with respiratory symptoms among children in Parit Raja, Batu Pahat	The study used a cross sectional comparative study on 104 children aged 3-12 years regarding respiratory symptoms. Groups were selected based on the distance of the house to the industry, the exposed group (5 km from the industry) and the comparison group (>5 km from the industry).	There were significant differences in respiratory health symptoms of cough and phlegm in the exposed and comparison groups at $p = 0.038$ and $p = 0.008$, respectively. Phlegm was associated with duration of stay in the current area for the exposed group (OR = 5.149, 95% CI = 1.080 - 18.365). On the other hand, sputum and cough were associated with distance from the industrial area by (OR = 3.889, 95% CI = 1.004 - 15.068) and (OR = 6.707, 95% CI =



				1,406 - 31,989).
2	(Leogrande et al., 2019)	Industrial air pollution and mortality in the Taranto area, Southern Italy: A difference-in-differences approach	A cohort study was conducted on all subjects (321,356 people) living in the Taranto area in 1998-2010. The study observed 15,303 natural deaths in the cohort and annualized mortality rates by age were calculated for each area unit (11 areas in total). PM ₁₀ and NO ₂ concentrations measured at air quality monitoring stations and results from dispersion models were used to estimate the population-weighted annual average exposure to industrially derived PM ₁₀ for each year. Changes in exposure and mortality were analyzed using Poisson regression.	Estimated percent increase in natural mortality of 1.86% (95% confidence interval) (CI): -0.06, 3.83%) relative to the 1 µg/m ³ variation in industrial PM ₁₀ . There was a 2.37% (95% CI: 0.31, 4.47%) increase in natural mortality (REM p-value = 0.22) among subjects aged 65+ years. There were increased results for For respiratory mortality, 8.74% (95% CI: 1.50, 16.51%) with no evidence of modified effect by age (REM p-value = 0.96).
3	(Paolocci et al., 2020)	Industrial Pollution and Respiratory Health Status	Air and individual characteristics, exposure history, and medical history	PM ₁₀ emissions from ports were associated with lower lung function parameters (FEV1: $\beta =$



	among Residents in an Industrial Area in Central Italy	information was accumulated through a validated questionnaire. Long-term exposure to industry, ports, biomass combustion (PM ₁₀) and urban traffic (NO _x) at residential addresses was assessed using a Lagrangian dispersion model. Association between exposure to wheezing and dyspnea symptoms was assessed using a logistic regression model, while a modified Poisson regression model was used to evaluate symptoms of cough with phlegm. Association between exposure and lung function was analyzed using mixed-effects linear models and cross-correlation.	-0.12, 95% CI -0.21 - 0.03; p = 0.02; FEV1/FVC: β = -1.67, (-3.10 -0.23); p = 0.02 while vessel emissions were associated with decreased FEV1 (beta = -0.12; 95% CI -0.21. -0.02), FEV1/FVC (beta = -1.67; CI 95% -3.10.-0.23), and FEF25-75 (beta = -0.12; CI 95% -0.21. -0.02). Exposures greater than 0.04 $\mu\text{g}/\text{m}^3$ in PM ₁₀ concentration from the harbor was associated with a decrease in FEV1 and FEF25-75 a decrease of 12 mL.	
4	(Genowska et al., 2023)	Emission of Industrial Air and Pollution	Research conducted with an analysis using retrospective	Infants born in areas with very high Total Particle Pollution



	Mortality Due to Respiratory Diseases: A Birth Cohort Study in Poland	cohort of a birth dataset covering 2,277,585 children from all countries in Poland. The birth data were analysed with 248 deaths data for under one year old caused by respiratory diseases. Dependent variable was time to death during the first 365 days of life. Survival analysis was conducted using Cox proportional hazards models for emissions at the mother's and child's place of residence, adjusting for individual characteristics, demographic factors, and socioeconomic status associated with contextual levels.	emissions tend to get significantly higher risk of death from respiratory diseases: hazard ratio (HR) = 1.781 [95% confidence interval (CI): 1.175, 2.697], $p = 0.006$, in comparison to infants born in areas with the lowest emission levels. This happened when significant factors adapted at the individual and contextual levels (HR = 1.959 [95% CI: 1.058, 3.628], $p = 0.032$).
5 (Mizutani et al., 2023)	An Evaluation of the Impact of Air Pollution on the Lung Functions of High School Students Living in a Ceramic	Evaluating the lung function of public high school students in SG, RC, and São Pedro (SP) (control site), Brazil,	Students living in SG had lower mean FVC and FEV1 compared to students living in RC and SP ($p < 0.05$),



	Industrial Zone	Park	in 2018 using cross sectional study. Asthma prevalence, mean PM ₁₀ , FVC (forced vital capacity), and FEV1 (expiratory volume in the first second) were compared between sites. Analysis using regression.	and students living in RC had lower mean FVC and FEV1 than those living in SP (p<0.05). PM ₁₀ was highly associated with the prevalence of FEV1 below LLN (r=0.99 and p=0.02) and FVC below LLN (r=0.98 and p = 0.09).
6	(Al Okla et al., 2024)	The Impact of Air Pollution on Asthma Severity among Residents Living near the Main Industrial Complex in Oman: A Cross-Sectional Study	The method used was cross-sectional. State health clinic records for patient visits related to asthma were collected over the period 2014 to 2022. Exposure such as distance from SIP, MIA, and Sohar Industrial Zone (SIZ) to determine high, medium, and low exposure zones (<6 km, 6-12 km, and >12 km, respectively). Modification of exposure effects by age, gender, and smoking status were also assessed.	Study on 410 patients (46.1% males and 53.9% females) living in more than 17 areas around SIPs stated that 73.2% of asthmatics were under 50 years old with severity significantly associated with proximity to the harbor. Risk ratios were estimated at (RR: 2.42; 95%CI: 1.01-5.78), (RR: 1.91; 95%CI: 1.01-3.6), and (RR: 1.68; 95%CI: 0.92-3.09) for SIP, MIP, and SIZ areas, respectively compared to control areas. Asthma and age have a more prominent



			association for males than females.
7	(Mukta et al., 2020)	Seasonal variations of gaseous air pollutants (SO ₂ , NO ₂ , O ₃ , CO) and particulates (PM _{2.5} , PM ₁₀) in Gazipur: an industrial city in Bangladesh	This study assessed the impact of seasonal variations on the abundance of atmospheric gaseous (SO₂, NO₂, O₃, CO) and particulate (PM_{2.5} and PM₁₀) air pollutants in Gazipur city. Data on pollutants was collected using the Continuous Air Monitoring Station (CAMS) (CAMS-4, Gazipur) of DoE in October 2017 to September 2018. The study revealed that the lowest concentrations of air pollutants during the rainy season were associated with the leaching effect of rainfall to pollutants in atmosphere. There was a moderate correlation (R² = 0.58) between CO and O₃ pollutants. The pollutants were derived from the atmosphere through photochemical reactions that were related to volatile organic compounds (VOCs). PM_{2.5} showed a positive correlation with PM₁₀ indicating that PM_{2.5} and PM₁₀ are generated from the same pathway fossil fuel combustion by motor vehicles and industrial activities.
8	(Bergstra et al., 2022)	The association of specific industry-related air pollution with occurrence of chronic diseases:	This study used cross-sectional, specifically register-based repeated type. The study was among 89,714 subjects Exposure to PM₁₀ and NO_x (per µg/m³) was significantly associated with cardiovascular treatment



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A register-based study (2012) with 536,599 yearly observations (2012-2017) that lived around large industrial area in the Netherlands. The association between yearly exposure (concentration and duration) for particulate matter (PM₁₀), sulfur dioxide (SO₂), nitrogen oxides (NO_x), and volatile organic compounds (VOCs). with medications given every year for respiratory diseases, cardiovascular diseases, diabetes mellitus, and inflammatory conditions were analyzed using multivariate logistic regression with generalized estimating equations (GEE), that the confounding was controlled.

(OR 1.06, 95%CI% 1.06-1.06 and OR 1.01, 95%CI 1.01-1.01). Exposure to PM₁₀ and SO₂ (per µg/m³) was significantly associated with treatment for inflammatory conditions (OR 1.05, 95%CI 1.00-1.09 and OR 1.07, 95%CI 1.01-1.14). SO₂ exposure was inversely associated with respiratory disease (OR 0.91, 95% CI 0.86-0.97).



9	(Brooks et al., 2023)	Health consequences of small-scale industrial pollution: Evidence from the brick sector in Bangladesh	The study was conducted in 10 administrative units in Mirzapur district in Dhaka Division. Ten unions were selected to sample participants in the research population from the Child Health Research Foundation (CHRF) longitudinal demographic and disease surveillance study. Respondents were categorized as exposed and less exposed to kilns (defined as at least one kiln within 2 km).	PM _{2.5} of 72.3 $\mu\text{g}/\text{m}^3$ (95% CI: 10.2, 134.3) was higher in the area 2 km downwind from the brick kiln during the brick production season. There were 2.2 times greater odds of suffering from COPD in adults over 40 years old and 4.2 times (95% CI: 2.7, 6.8) greater odds in adults over 18 years old. Among children younger than 5 years, there were greater odds for respiratory symptoms (2.1, 95% CI: 0.7, 6.0) and asthma symptoms (2.5, 95% CI: 0.1, 96.1), but the results were less robust for the smaller sample of children.
10	(de Lira-Quezada et al., 2024)	The association of air pollution in respiratory allergy: Its impact in an industrial city	A total of 240 subjects over 6 years of age living in the metropolitan area of Monterrey, Nuevo León, Mexico, with a diagnosis of allergic rhinitis and/or asthma, were included.	Association between pollutants and RCAT, ACT, and spirometry results of subjects at 14 stations were established. PM ₁₀ and forced vital capacity (FVC) had $r = 0.074$ with $p = 0.005$, PM ₁₀ and absolute FEV1/FVC ratio



Subjects' addresses were registered in a database and the rhinitis control assessment test (RCAT) and asthma control test (ACT) were applied. Data of environment were collected from Nuevo León Environmental Monitoring System (SIMA). The geolocation of industries and roads adjacent to the subject's address and SIMA station was obtained through a geographic information system using ArcGIS software.

showed $r = 0.102$ with $p = 0.000$; The distances found to be associated with worsening respiratory symptoms were living 165 m from a main road or 241 m from an industrial site.

Discussion

The results of the literature review show that distance from the source area of exposure to air pollutants has a significant association with the occurrence of respiratory disorders. Distance from industrial areas has a significant difference in respiratory symptoms of cough and phlegm. (Farihah Mohmad Shamsuddin, Jalaludin and Haslina Hashim, 2022). Meanwhile, another study found that a distance of 165 m from a highway or 241 m from an industrial area was associated with



worsening respiratory disease symptoms (de Lira-Quezada et al., 2024). Asthma sufferers are more prevalent in locations with high exposure zones and close to industrial areas. (Al Okla et al., 2024). This can happen because people who live near industrial areas will be exposed to industrial air pollutants more frequently and have a greater chance of developing respiratory diseases. Industrial pollutants can cause the release of pauci-micronic molecules, which are delivered to the upper and lower airways. Excess oxidants produced by pollutants will result in the accumulation of reactive oxygen species (ROS) and nitrogen that will eventually lead to tissue inflammation and cell apoptosis; these have been established in oxidative stress. Therefore, these factors lead to increased respiratory symptoms (de Lira-Quezada et al., 2024). If the more frequent and more exposure to pollutants received by the respiratory system, the more reactive oxygen accumulates so that it can produce more oxidative stress that causes inflammation.

In addition, it appears that patients exposed to air pollutants have a high risk of death. This mortality risk may also be related to the place of residence and the air conditions around the patient. Infants born in areas with very high Total Particle Pollution emissions have a significantly higher risk of dying from respiratory diseases compared to those born in areas with the lowest emission levels. Newborns and infants are particularly vulnerable to industrial air pollution. There is a specific increase in the risk of death from respiratory disease between days 50 and 150 of life. This may occur due to the cumulative effect of critical negative factors during early infancy, for example, immunological, immaturity and worsened response to infection, poor defense



mechanisms, incomplete vaccination schedule, or transient iron deficiency (Genowska et al., 2023).

The risk of death from respiratory diseases also occurs in the elderly (65 years and above). Statistical tests show that there is an association between industrial PM₁₀ and mortality risk. For short-term exposure to particulate matter, elderly people experienced the highest risk of death (Leogrande et al., 2019). Another study also had similar results that the highest mortality from respiratory syncytial virus (RSV) and influenza in the United States in 1999-2018 occurred in the elderly group (65 years and older) (Hansen et al., 2022). The elderly is a group prone to mortality because the elderly have complex multimorbidity and pre-existing disease symptoms and are more susceptible to respiratory viral infections than healthy young adults due to various factors. Thus, elderly patients may present with respiratory viral infections or pneumonia. Elderly patients may also experience it without fever or common respiratory symptoms. Often, elderly people instead experience exacerbations of chronic diseases, including heart failure, chronic kidney disease, COPD or diabetes (Watson and Wilkinson, 2021).

In this review, it was also found that lung capacity is also related to air pollutants. Several articles in this review had similar results, that there is a decrease in FEV₁ (expiratory volume in the first second) of the lungs in places exposed to air pollutants. Most studies evaluating the impact of air pollution on lung function in children and adolescents found that populations exposed to air pollutants had impaired lung function parameters, with a tendency for FEV₁ to be affected more than FVC (vital capacity) (Mizutani et al., 2023). Another study had similar results in that



participants exposed to PM₁₀ and O₃ had a higher risk of having lung function below the lower limit of normal (LLN) for FEV1 and FVC, but not the ratio - indicating that the effect was more about lung volume, rather than obstructive effects. The association was observed across all susceptibility windows suggesting that early life exposure to air pollution impacts lung function into adulthood (Nordeide Kuiper et al., 2021).

Conclusion and Recommendation

The results of the literature review show that distance from the exposure source area is significantly related to the occurrence of respiratory disorders. In addition, related to the impact of air pollution, patients exposed to air pollutants are more at risk of death from respiratory disorders. The groups at highest risk of death are infants and the elderly. Air pollutants also play a role in reducing the expiratory volume in the first second (FEV1) of the lungs.

Industries need to control the risk of air pollution so that the impact of air pollution on workers and the surrounding community can be minimized. Industries can conduct emission tests and report on exhaust emission control periodically, and ensure that exhaust emissions meet applicable quality standards.



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