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IMPACT OF AIR POLLUTANTS ON CHILDREN'S RESPIRATORY HEALTH (CASE STUDY: INDUSTRIAL AREA)

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Abstract

The fifth biggest cause of death globally due to respiratory and cardiovascular diseases, air pollution has been steadily increasing over the last several years. This article's goal is to provide a synopsis of a number of pertinent studies that discuss the concentration of pollutants caused by industrial emissions, the impact of being close to the industry, and the consequences of these variables on respiratory health. A systematic review approach is used in this piece. Three scientific databases—ProQuest, PubMed, and ScienceDirect—conducted a literature search for articles published during the last decade. Study participants had to be either children or teenagers, there had to be at least one site in an industrial region, the study had to deal with respiratory symptoms, respiratory illness, and/or pulmonary function testing. Only seven papers out of two hundred and twenty-two were ultimately considered for inclusion in the systematic review. Both pollution concentrations and children's respiratory difficulties are shown to be greater in locations close to industries as opposed to places further away, according to the included publications.

Keywords: Air Pollution, Respiratory Health, Industrial Area

Introduction

The fifth biggest cause of death globally due to respiratory and cardiovascular diseases, air pollution has been steadily increasing over the last several years. If the impact of COVID-19 appears within a few weeks, the health impacts of air pollution may appear later and cause chronic diseases such as respiratory and cardiovascular disorders that make individuals much more vulnerable[1,2]. The rapid development of industry in various countries has made industrial activities one of the contributors to air pollution today. This is due to poor air quality and many countries lacking information regarding sustainable environmental management[3].

Although many studies have shown that exposure to industrial emissions increases the risk of respiratory disorders. However, there are still industries operating near settlements. Studies in children who live < 2 km from the chipboard industry show that they have a greater prevalence of respiratory symptoms such as cough and throat irritation. Therefore, children cannot go to school and increase the number of hospitalizations[4]. This is caused by exposure to pollutants from industrial emissions such

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as PM2.5, PM10, SO2, NO2, CO, and O3. This pollutant is produced by various industrial activities that use energy sources such as coal or crude oil[5].

This air pollutant irritates the respiratory tract and disrupts the mechanism in the respiratory system[6]. So that it can trigger coughing, wheezing, and dyspnea. Even if the condition persists, this can worsen respiratory conditions such as asthma, and even can cause lung cancer, as research in China shows that long-term exposure to air pollution significantly increases the risk of asthma, wheezing, and phlegm[7,8]. Other studies also show that long-term exposure to air pollution is associated with the incidence of lung cancer. This increases in line with an increase in pollutant concentrations[9,10]. The most vulnerable groups to this pollutant exposure are children. This is caused by the ongoing process of lung growth and development, an incomplete metabolic system, spending more time outdoors, and having a higher level of ventilation than adults. Therefore, the dose of pollutants can reach the lungs in children more than adults[11].

There have been many studies that show the impact of exposure to industrial emissions on respiratory health such as its effect on workers, the increasing number of patients with respiratory disorders who enter hospitals both in adults and children. However, only a few studies have considered the impact of industrial emissions on children's respiratory health based on their proximity to the industry. By considering this, it can help prevent and manage the health impacts caused by industrial emissions. This systematic review summarizes some relevant articles covering the impact of exposure industrial pollutant on children's respiratory health based on their proximity to industry.

Method

Search Strategy

This review was retrieved through ProQuest, PubMed, and ScienceDirect for relevant articles. The searching process contained three terms, "air pollution" and "respiratory health" and industrial. In ProQuest, " air pollution" and "respiratory health" and industrial are used as keywords where the source type is a scholarly journal, full text, the publication date is the last ten years, the article is in English, the subject is sulfur dioxide or industrial plant emissions entered in the search filter. In PubMed, search strategy were "air pollution"[All Fields] AND "respiratory health"[All Fields] AND ("industry"[MeSH Terms] OR "industry"[All Fields] OR "industrial"[All Fields]) AND ("loattrfree full text"[sb] AND "2014/09/12"[PDat] : "2024/09/09"[PDat] AND "humans"[MeSH Terms]). In ScienceDirect, article types represent research articles, publications in the past 10 years, and articles represent full access used in the search filter.

Selection Criteria

This systematic review was conducted using a predefined protocol based on Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)[12]. This review includes academic research with epidemiologic studies that discuss the relationship between pollutants sourced from industry and respiratory disorders in children or adolescents who live around them. Articles with studies of workers in industry and discussing pollutants with mortality or hospitalization are excluded.

Results

A Literature search was carried out on three scientific databases namely ProQuest, PubMed, and ScienceDirect producing 202 articles. In the screening process, 4 articles were excluded due to duplication, 181 articles were issued based on titles and abstract discrepancies with inclusion criteria to produce 17 articles for full-text review. Then, 10 articles were excluded based on the incompatibility of content with inclusion criteria and 7 articles were deemed suitable for inclusion in the review (Figure 1). Exposure to pollutants can irritate the respiratory tract which triggers symptoms such as coughing, wheezing, and aggravating asthma so patients will be more vulnerable to respiratory infections. In addition, some of the studies included in this review also measure lung function and FeNO levels to determine the presence of respiratory impairment caused by exposure to pollutants (Table 1).

3.1 Image

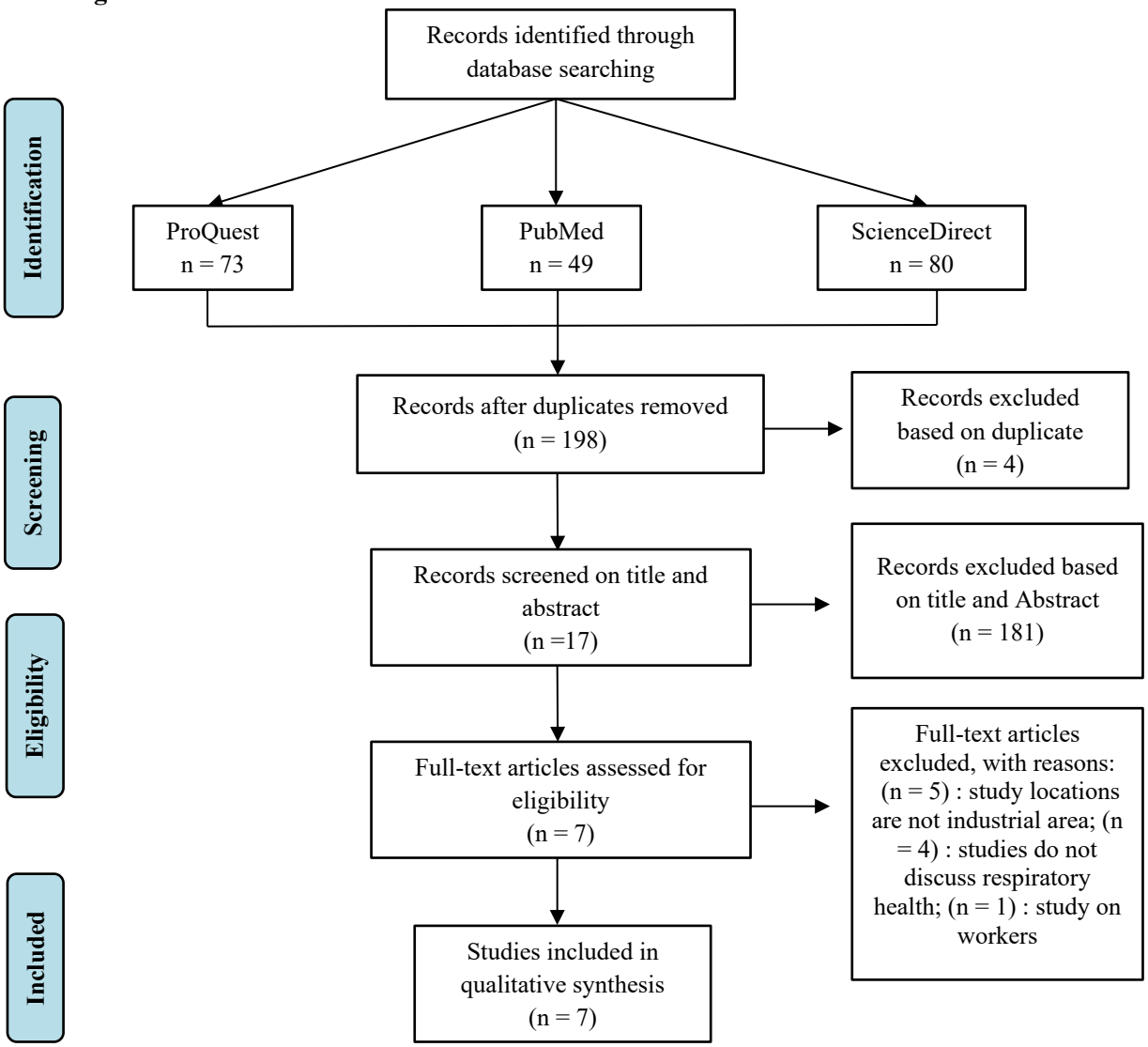

Figure 1. Flow Diagram for Selection Studies (PRISMA)[12]

Respiratory symptoms and diseases

From the included studies, one of the respiratory symptoms experienced by children who live around the industry is a dry cough. Studies in school children around the Netherlands industry with a distance of 2 - 35 km show that exposure of PM2.5 was significantly elevated with symptoms of dry cough(13). Another study showed that dry cough was higher in children who lived 5 km from industry than those who lived farther away > 20 km from industry[14]. Studies in children around the Mexican industry show that wheezing in school children who are closer to industry (1100 m) is higher than school children II (7300 m). This study also showed an increase of 10 µg/m3 O3 concentration was associated with an increase in wheezing in school children near the industry[15]. In addition to triggering symptoms, exposure to pollutants can also aggravate respiratory diseases such as asthma. One of the studies showed that SO2 exposure in children who lived 4.3 km from industry had an increased hazard of asthma onset compared to those without an industry within 7.5 km around their home16. In line with research in Estonia which shows that children who live 5 km from the industry have a higher asthma prevalence compared to those who live > 20 km from industry (p<0, 05)(14)]. Another study also showed that children who lived ≤ 10 km from industry had asthma higher than children who lived > 10 km during the study period[17].

3.2 Table

Tabel 1. Article Characteristics

Authors	Study Design; Study Period	Subject	Tool	Outcome
Bergstra *et al.,*13	Cross sectional; 2012 –2013	School children Aged : 7 – 13 years living around industrial area (2 - 35 km)	• Air quality data ($PM_{2.5}$, NO_X) from monitoring station • ISAAC questionnaire • Lung function test	• Among children exposed to $PM_{2.5}$ and NO_x have lower PEF values (p <0.05). • Exposure of $PM_{2.5}$ significantly elevated with dry cough (OR 1.40, 95% CI 1.00 - 1.94).
J. Idavain *et al.,*14	Cross sectional; 2019	1326 children Aged: 8 – 12 years a. Exposed: living in Ida-Viru Counties (5 km) b. Reference: Living in Lääne-Viru Counties or Tartu County (> 20 km from industry)	• Air quality data ($PM_{2.5}$, PM_{10}) from monitoring station • Questionnaire • FeNO test	• Wheezing and dry cough in exposed children were higher than children living in the reference area (p <0.05). • FeNO levels in exposed children (95% CI 1.03-2.60) are 1.63 times higher than children who live in the reference area (p <0.05). • $PM_{2.5}$ was associated with FeNO level.
Dąbrowiecki P *et al.,*15	Cross sectional; 2019	Children were recruited from 6 primary schools in Gdynia (258 children) and 10 primary schools (512 children) in Zabrze, Poland Aged: 9 - 15 years	• Air quality data ($PM_{2.5}$, PM_{10}, SO_2, and NO_2) from Chief Inspectorate for Environmental Protection (CIEP) • Spirometry test • Questionnaire	• Seasonal rhinorrhea was significantly higher in Zabrze than in Gdynia (p = 0.015). Cough episodes were higher in Zabrze than in Gdynia (p = 0.022). • Mean FVC, FEV1, and PEF values were higher in children in Gdynia than in Zabrze (p ≤ 0.032). • The concentration of PM10 in Zabrze is higher than in Gdynia at around 30.1 - 35.0 µg/m^3, in some areas of Zabrze it reaches 35.1 - 40.1 µg/m^3.
Buteau *et al.,*16	Cohort; 2002 – 2011	722,667 children a. Exposed (a major industry within 2.5 – 7.5) b. Unexposed (no major industry within 2.5 – 7.5 km from the residence)	• Asthma diagnoses were identified using ICD-9 and ICD-10 data • Industrial emissions data ($PM_{2.5}$, NO_X) from monitoring station	• Children living 4.3 km from industries that emit SO_2 had an increased the hazard of onset asthma 8.9% (95% CI: 2.8, 6.4%) compared to those who do not have industry within 7.5 km from their home. • Each increase in emissions (tons) of $PM_{2.5}$ and SO_2 is associated with an increased hazard of onset asthma.
Chiang *et al.,*17	Ecology; 2009 – 2011	587 children Aged: 11 - 14 years	• Air quality data (SO_2) from monitoring station	• Asthma in children at HE 1.60, 1.28, and 1.29 times higher than children at LE

		a. High Exposure/ HE (≤ 10 km) b. Low Exposure/ LE (> 10 km)	• Health outcomes data from Taiwan Health Insurance database	(2014, 2015, and 2016).
Acat *et al.,*18	Cross sectional; 2015	387 children a. School I (3.3 km) b. School II (8.8 km) c. School III (27.7 km from the industy)	• Questionnaire • Air Sampling PM_{10} and SO_2 • Lung function test • FeNO test	• FeNO levels at Schools I and II higher than School III ($p < 0.001$). • PEF values at School I lower than Schools II and III ($p = 0.002$).
Chen *et al.,*19	Cross sectional; 2014 – 2016	2532 children Aged: 7 – 16 years a. Heavy pollution primary school (near industry) b. Llight pollution primary school (surrounded by extensive distribution of green belt)	• Air quality data ($PM_{2.5}$, PM_{10}, NO_2, SO_2, CO, O_3) from school monitoring station • Questionnaire • Lung function test	• FVC, FEV, PEF, and FEV_1 are lower in school children at heavy pollution than those in light pollution. • Lung function impairment is higher in school children at heavy pollution (OR = 1.768, 95% CI 1.01 - 1.10)

Lung function and FeNO Levels

Several studies also discuss the relationship of pollutants with lung function. One of the studies showed that children exposed to PM2.5 and NOX had a lower PEF percentage[13]. Other studies show that school children who are close to the industry have lower FEV1, FVC, and PEF scores compared to children who are farther away[15,19]. However, one study did not mention the distance of residence of the study population, only stated that subjects in "heavy pollution" were near the industry while others were far from the industry (19). The effects of pollutant exposure can also be seen based on the level of FeNO where two studies showed the level of FeNO in children living or schools near to the industry is higher than those who are farther away[14,18].

Discussion

This review describes the health effects of breathing due to exposure to pollutants from industrial emissions in children. Pollutant exposure is a factor that can affect respiratory health. Based on the included studies, some industries around settlements or schools are the iron and steel industry, oil shale, coal power plant, thermoelectric plant, an aluminum smelter, and petrochemical plant[13–15,17,18]. Although the types of industries are very diverse, primary pollutants such as PM2.5, PM10, SO2, NOX, NO2, CO, and secondary pollutants such as O3 can be produced by industrial activities from the use of energy sources such as coal or crude oil in the process[20,21]. Most of the studies assessed exposure using data from air monitoring stations as in the study in Mexico which shows that pollutants such as PM10, SO2, and NO2 have exceeded WHO ambient air quality standards[15,22]. Although the concentration of pollutants is still below the quality standard, if exposure continues, this can affect the respiratory health of those who live nearby. Research shows that long-term exposure to pollutants such as PM10 and PM2.5 was associated with a decrease of FVC, FEV1, and respiratory symptoms[23,24].

Besides being caused by the concentration of pollutants themselves, the respiratory effect can also be influenced by factors such as proximity to industry. Most studies show that pollutant concentrations or the amount of emissions in areas close to industry are higher than those far away[13–16]. Although this factor is also influenced by meteorological factors such as temperature, humidity, direction and wind speed[25–27]. Pollutants will move in the direction of the wind and can travel longer distances when the wind speed is high enough[28,29]. Study in China shows the dispersion of pollutants in that area caused by cold winds and strong northwestern winds above 850 hPa so that most pollutants can travel longer distances(30). Most of the studies in this review have considered these

meteorological factors where the location of the study is in the direction of the wind from the industry[13,16–18]. Therefore, it can be said that children who are near the industry will be constantly exposed to pollutants produced from the industry and experience their health impacts. Most studies show that children who are closer to the industrial area around 1.1 km to km 10 km have higher respiratory symptoms or diseases compared to those farther from the industry[14–17].

There are several international environmental policies as an effort to address environmental issues, namely the United Nations Framework Convention on Climate Change, the United States Environmental Protection Agency (USEPA), the European Union Environmental Policy, and China's Environmental Protection Policies. These policies play an important role in preventing global pollution, promoting sustainable development, and conserving natural resources. These policies address a variety of environmental issues, including biodiversity loss, climate change, and pollution. Through international conventions and agreements, countries collaborate to set goals, develop strategies to address environmental threats, and establish regulations[31].

The study included in this review shows the association of exposure to industrial emissions on the respiratory effects of children which is seen based on its proximity to the industry. However, there were inconsistencies in each of the included studies. So this review is not yet feasible to make a meta-analysis. There are several limitations to this systematic review. First, categorizing research subjects based on their proximity to industry and requiring the measurement of pollutant concentrations or the amount of emissions in the study led to a reduction in the number of studies that entered. Then, different methods of determining pollutant concentrations and environmental conditions for expressing near and far distances from industry in each study have made it impossible to deduce safe distances to prevent the effects of industrial emissions exposure. This is why it cannot draw conclusions explicitly and can only describe the impact of pollutant exposure on respiratory health by considering proximity to industry.

Conclusion

Children who live or have activities around the industry are the most vulnerable group to experience respiratory problems because they will be continuously exposed to pollutants emitted by industry. However, the different methods used in determining the concentration of pollutants and different environmental conditions in each study caused the inability to conclude a safe distance to prevent the impact of industrial emissions exposure. This indicates the need for further studies related to this topic.

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