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RESEARCH **Open Access**

The Effect of Air Quality Parameter on Respiratory Diseases: A Systematic Literature Review

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Abstract
The issue of the air quality index and its impact on health, specifically human respiratory continues to be a global concern. Recent studies indicate that respiratory diseases are linked to the inflammation caused by air pollutants. The aim of this study was to review the correlation between air quality measurements and factors contributing to the rise in acute nasopharyngitis and other respiratory disorders. This study was a systematic literature review of English language articles published in peer-reviewed academic journals between January 1, 2018, and April 30, 2023. This study found that twelve eligible papers from five reputable electronic databases: PubMed, Springer, ScienceDirect, ProQuest, and Google Scholar were eligible included. Severe respiratory illnesses are caused by factors such as Particulate Matter (PM), nitrogen dioxide (NO2), sulfur dioxide (SO2), carbon monoxide (CO), ozone (O3), and air temperature. While all studies showed a direct association between these factors and respiratory diseases, the inconsistent association between O3 and AQI with respiratory disease may be attributed to differences in sample size and geographic settings. A comprehensive review study involving human subjects is necessary to validate these findings.

Keywords: Air Pollution, Air Quality Index, Inflammation, Respiratory Diseases.

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1. INTRODUCTION

The pace of urbanization has had a profound impact on the standard of living and material prosperity, but it has also engendered environmental issues, including air pollution, that pose a significant threat to respiratory health (Castner et al., 2017; Deng et al., 2016; Guan et al., 2016; Jiang et al., 2016; Olaniyan et al., 2017; Zhao et al., 2016; Zhou et al., 2016). Long-term exposure to pollutants in the air has been linked to a reduced quality of life and lower socioeconomic status, particularly in urban areas with high population density and industrial activity (Liu & Wang, 2016; Tan et al., 2023). According to the World Health Organization, air pollution is responsible for approximately 2.4 million deaths annually (Li et al., 2019). These figures alarm the importance of air pollution's impact on respiratory-related health.

The high formation of free radicals and reactive oxygen species and the overexpression of inflammatory cytokines reduce cell antioxidant capacity and lead to inflammatory damage (Zhang, et al., 2019). The effect of pollutants on respiratory disorders is influenced by various factors, including local air pollutant concentrations and meteorological conditions (Zhu et al., 2023). Swanton et al., (2022) discovered a relationship between particulate matter (PM) pollution and the presence of mutant epidermal growth factor receptor (EGFR), which promotes the development of lung cancer by encouraging progenitor-like cells. Zeng et al., (2023) discovered a relationship between glutathione s-transferase (GST) gene deletion polymorphisms caused by air pollution and mucus in the nasal cavity biomarkers and pulmonary health.

Respiratory diseases can be caused by a variety of factors, including particulate matter (PM), carbon monoxide (CO), nitrogen dioxide (NO2), ozone (O3), and sulfur dioxide (SO2). PM can accumulate in the upper respiratory tract, such as the nasopharynx, and may lead to acute nasopharyngitis and other respiratory illnesses. Symptoms of acute nasopharyngitis include fever, a runny or congested nose, and muscular pain (Zhang, et al., 2019). SO2 can dissolve in water, forming SO3- and SO4-, which can cause lung diseases (Yang et al., 2020). NO2 can enter the lungs and create nitrous acid (HNO2) and nitric acid (HNO3), both of which can harm tissues. CO binds strongly to hemoglobin, leading to a lack of oxygen in the body. Inhaled O3 can result in inflammation of the lining of the lungs (Abdelrahman et al., 2022; Traber & Bradford, 2019). PM originates mainly from combustion byproducts, including diesel fuel and power plant exhaust. SOx is a toxic gas that is highly irritating and is mostly produced by the burning of coal and other sulfur-containing fuels. NOx and CO primarily come from industrial or motor vehicle emissions, whereas O3 comes from the atmosphere (Hu & Guo, 2021). Therefore, exposure to PM, SOx, NOx, CO, and O3 is practically unavoidable and carries a high risk of causing acute nasopharyngitis and other respiratory diseases.

Consequently, there is an urgent requirement for a thorough investigation into the respiratory health risks posed by pollutants. This paper aims to scrutinize the association between exposure to air quality indicators and predictors of a higher incidence of acute nasopharyngitis and other respiratory disorders in numerous relevant studies. Researchers can use this article as a resource to develop intervention programs that monitor ambient air pollution levels, especially in high-pollution areas, to prevent the spread of acute nasopharyngitis and other respiratory illnesses. By doing so, they may be able to reduce the number of individuals who suffer from the adverse effects of air pollution.

2. RESEARCH METHOD

This systematic review was conducted per the updated PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. The components of the mnemonic PEO (Population, Exposure, Outcome) were as follows:

- Population: general or hospital-based population
- Exposure: air pollution
- Outcome: respiratory diseases

Databases and search strategy for this systematic review specifically examines the impact of air pollution on Acute Nasopharyngitis and other respiratory diseases. The review includes pertinent English language articles published in peer-reviewed academic journals between January 1, 2018, and April 30, 2023. The search was conducted in electronic databases such as PubMed, Springer, ScienceDirect, ProQuest, and Google Scholar using relevant keywords. The data collection process involved a combination of keywords using the Boolean operator. The specific English search terms used can be found in Table 1. All retrieved articles were exported using Microsoft Excel to identify duplicate articles.

Table 1. Keywords of searching strategy

Key concepts	Search terms
Acute Nasopharyngitis, respiratory diseases, and air pollution	"Acute Nasopharyngitis" OR "respiratory diseases" OR "air pollution" OR "air quality" OR "particulate matter"
Pollutant	"Carbon monoxide" OR "CO" OR "sulfur dioxide" OR "SO2" OR "particulate matter" OR "nitrogen dioxide" OR "NO2" OR "ozone" OR "O3"
Linkage	"Association" OR "relationship" OR "influential factor" OR "link"

The inclusion criteria applied were: (1) Published in English between 2016 and 2023 (2) Focuses on ambient air pollutants (3) Original articles related to the impact of air pollution on acute nasopharyngitis and other respiratory diseases (4) Exclude qualitative studies and non-original articles. The study reviews research articles on air pollution, acute nasopharyngitis, and other respiratory diseases. It includes individuals exposed to air pollution and experiencing these conditions, regardless of race or ethnicity.

Study selection used Two reviewers checked titles and abstracts against inclusion criteria. A third reviewer resolved disputes. A full-text screening followed to exclude irrelevant literature.

Quality assessment and data extraction. Two reviewers independently assessed the quality of the article using different checklists for cross-sectional and cohort studies. These checklists covered the "Sampling," "Exposure," "Confounding factors," "Outcomes," and "Statistical analysis" domains, with a maximum score of 8 for cross-sectional studies or 11 for cohort studies. Each item was rated as Yes (score of 1), No, or Unclear (score of 0). Non-applicable items were excluded from the overall score. Cross-sectional or retrospective cohort studies with a score of ≥6, or prospective cohort studies with a score of ≥8, were considered high-quality articles. Any disagreements were resolved through discussion among three reviewers.

We first extracted data from each article into an extraction table by referencing the title and abstract, and then conducting a full-text screening. Any disagreements in article inclusion were discussed with a third reviewer. Table 2 displays the retrieved data from the articles, presenting details such as the first author's name, year of publication, study design, number of subjects, outcomes, and air pollution parameters.

The selected articles will be analyzed to extract relevant information such as author, year, title, objectives, methods, and research results. The results will be reviewed for their association with acute nasopharyngitis, other respiratory diseases, and air pollution.

3. RESULTS AND DISCUSSION

During the retrieval process, a total of 1 article from PubMed, 17 articles from Springer, 20 articles from Science Direct, 136 articles from ProQuest, and 6 articles from other sources (Google) were gathered, resulting in a total of 180 articles. Following the screening procedure, we excluded articles published over 8 years ago, those not in English, non-research articles,

and those unrelated to the topic of interest, leaving us with 168 articles. After a thorough selection process, only 12 articles were deemed suitable for full-text assessment, as illustrated in the PRISMA flow diagram (Fig. 1). The findings from these 12 studies are included in this systematic review, as displayed in Table 2.

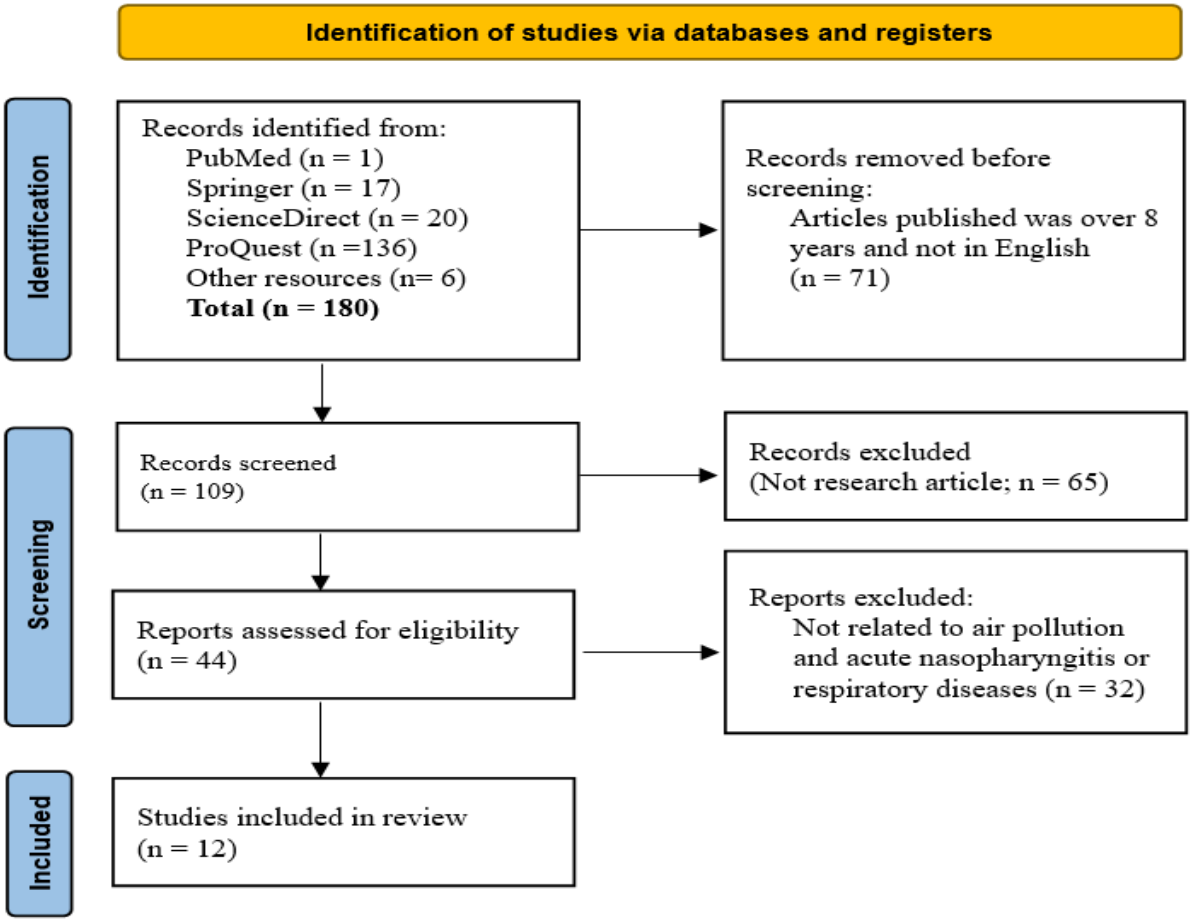

Figure 1. Study selection process

The included studies were published between 2018 and 2023, wherein 5 articles were retrospective studies, 1 prospective cohort study, 3 were longitudinal studies, 2 cross-sectional studies, and 1 case-crossover study. Seven studies were conducted in China, two studies were conducted in Italy, one study in Colombia, and one study was in Scotland. The total number of participants was 1,923,696, wherein 61.9% were from a case-crossover study, 13.1% from cohort studies, 24.6% from longitudinal studies, and 0.3% from cross-sectional studies. Two cohort studies had a sample size of <1000 participants (Bumroongkit et al., 2022; Morantes-Caballero et al., 2019).

Various studies have been conducted on air quality parameters (AQI). Specifically, two studies have focused on PM2.5 (Morantes-Caballero et al., 2019; Zhang, et al., 2019), while two others have investigated PM10 (Bumroongkit et al., 2022; Pegoraro et al., 2021). Additionally, seven studies have looked into multiple parameters such as NO2, SO2, CO, and O3, and one study has concentrated on AQI in general (Yu et al., 2021). Most of these studies have reported the annual concentrations of these parameters, except for those by He et al., (2023) and Li et al., (2023), which used certain lag times for mean pollutant levels. The results regarding respiratory diseases have shown variations across studies. Some studies have focused on a single disease, such as nasopharyngitis, Acute Pulmonary Embolism, Acute Exacerbation of Chronic obstructive pulmonary disease, Acute lower respiratory tract infections (ALRI), and Upper respiratory tract infection (URTI), while others have explored multiple outcomes related to respiratory diseases.

The association between pollutants exposure and respiratory diseases is consistent based on current evidence. PM2.5 and PM10 exposures were demonstrated to be associated with various respiratory conditions, including nasopharyngitis, COVID-19, Acute Pulmonary Embolism (ACE), ALRI, and URTI. Similar associations were proven between SO2, NO2, and O3 exposure and these respiratory diseases. Interestingly, Yu et al, (2021), demonstrated a whole air quality index (AQI) not significantly correlated with acute pharyngitis cases (Yu et al., 2021). Additionally, temperature was found to be the main independent factor causing acute pharyngitis. Interestingly, one study reported a protective role of O3 in causing pediatric URTI (Li et al., 2023).

The negative correlation findings in the relationship between O3 and AQI with respiratory disease may be partly due to the heterogeneous sample size and geographic settings (Int Panis et al., 2017; Yoda et al., 2014). Few studies reported small but consistent decreases in lung function associated with short-term ozone exposure, especially among children and adults with asthma. When using healthy individuals, the causality or the effect of pollutant exposure would be more shown. Also, epidemiological evidence shows that ozone exposure triggers bronchial inflammation and hyper-responsiveness; respiratory tract oxidative stress leads to allergic sensitization, morphological changes of the tract, and impaired host defense. Similar arguments can be made for the AQI, as it tracks various air pollutants and their effects on the respiratory system (Kim et al., 2020; Lu & Yao, 2023).

The major outdoor air pollutants we discussed are particulate matter (PM), ozone (O3), sulfur dioxide (SO2), and nitrogen dioxide (NO2). These pollutants pose a significant threat to human health, particularly in terms of respiratory diseases. They can cause a range of health problems, including cardiovascular and central nervous system malfunction, reproductive issues, and even cancer. Other pollutants like carbon monoxide (CO) can also cause damage to our cells when they enter our bodies through the airway system (Manisalidis et al., 2020; Yadav et al., 2021).

Exposure to environmental PM2.5 is a significant risk factor for chronic nasopharyngitis, with both short- and long-term exposure having adverse effects on health. Studies suggest that men and adults over 65 may be more susceptible to the short-term effects of ambient PM2.5, while younger individuals may be more vulnerable to its long-term implications (Zhang, et al., 2019). PM2.5 is also a significant contributor to chronic obstructive pulmonary disease (COPD) because it can cause oxidative stress (OS), which is a type of cell damage resulting from an imbalance between antioxidant defense mechanisms and the production of reactive oxygen species (ROS). Similarly, acute nasopharyngitis has also been associated with PM2.5 due to similar physiological processes, such as the excessive generation of free radicals, ROS, and inflammatory cytokines. This can lead to inflammatory damage, reduce cells' antioxidant capacity, and increase their intracellular Ca2+ concentration (Checa & Aran, 2020).

Table 1. Results of a review of studies on the linkage of air pollution to an increase in COVID-19

Author(s) (year)	Title	Study Location	Study design	Sample size	Outcomes	The Risk of Air Pollution Parameters
Zhang, et. al., (2019)	Short-term and long-term effects of PM2.5 on acute nasopharyngitis in 10 communities of Guangdong, China	Guangdong, China	Retrospective cohort	8871 residents	Nasopharyngitis	- Short-term For each 10 μg/m3 increase in concentration of $PM_{2.5}$, OR= 1.14; 1.08-1.21; AOR= 1.15; 1.07-1.23 - Long-term For each 10 μg/m3 increase in the concentration of PM2.5, HR= 1.13; 1.08-1.18; Adj. HR= 1.18; 1.12-1.24
Al Ahad, et. al., (2023)	Long-term exposure to air pollution and mortality in Scotland: A register-based individual-level longitudinal study	Scotland	Prospective cohort longitudinal	202,237 participants (general population)	Cardiovascular, respiratory, cancer, and other causes of mortality	- The mortality hazard from respiratory diseases was 1.062 (95%CI = 1.028–1.096), 1.025 (95%CI = 1.005–1.045), and 1.013 (95%CI = 1.007–1.020) per 1 μg/m3 increase in PM2.5, PM10 and NO2 pollutants, respectively.

Pegoraro, et. al., (2021)	An Italian individual-level data study investigating the association between air pollution exposure and COVID-19 severity in a primary-care setting	Italy	Longitudinal	6483 COVID-19 patients	Covid-19 patients with pneumonia	- PM10 ≤ 19.84 µg/m3 as the reference group - 19.84 µg/m3 < PM10 ≤ 28.73 µg/m3 with OR= 1.34; 1.09-1.65 - PM10 > 28.73 µg/m3 with OR= 1.93; 1.55-2.39
Chen, et. al., (2019)	The association between high ambient air pollution exposure and respiratory health of young children: A cross-sectional study in Jinan, China	Jinan, China	Cross-sectional	2532 primary school children	Acute nasopharyngitis, Acute bronchitis, pneumonia, Asthma Chronic nasopharyngitis, Allergic rhinitis, Other respiratory diseases	The increased odds of lung function impairment associated with exposure to higher air pollution could be up to 171.5% (aOR=2.715; 95% CI=1.915–3.849) for PEFb 75% predicted in 2014.
Li, et. al., (2023)	Double trouble: The interaction of PM2.5 and O3 on respiratory hospital admissions	Beijing, China	case-crossover design	1,191,308 respiratory admissions	Hospital admissions for respiratory diseases	During the warm season, PM2.5-O3 co-pollution had a significant effect on respiratory admissions. Compared to the reference group, the

						RRs for single high PM2.5, single high O3, and PM2.5-O3 co-pollution were 1.005, 1.007, and 1.029, respectively.
Marchetti, et. al. (2023)	Long-term Residential exposure to air pollution and Risk of chronic respiratory diseases in Italy: The BIGEPI study	Italy	Cross-sectional	4141 participants (general population)	Respiratory diseases (asthma, rhinitis, COPD)	We found associations between PM exposure and rhinitis (PM10: OR 1.62, 95%CI: 1.19–2.20 and PM2.5: OR 1.80, 95%CI: 1.16–2.81, per 10 μg/m3) and between NO2 exposure and CB/COPD (OR 1.22, 95%CI: 1.07–1.38 per 10 μg/m3), whereas asthma was not related to environmental exposures.
Nie, et. al., (2023)	Impact of air pollution on respiratory diseases in typical industrial city in the North China Plain	North China, China	Retrospective	32,025 respiratory hospital admissions	Respiratory diseases (asthma, bronchitis, upper respiratory tract infection (URTI), pneumonia, emphysema, COPD, and tuberculosis)	An increase of 1 _g/m3 in the average mass concentration of PM2.5, PM10, NO2, and SO2 in ambient air was associated with an elevated incidence of respiratory diseases by 0.2–1.4%, 0.7–1.6%, 3.7–8.2%, and 0.5–2.3%, respectively. Additionally, a monthly

						mean mass concentration of CO increased by 1 mg/m3 leading to a rise in pulmonary tuberculosis incidence by 2.9%.
Bumroongkit, et. al., (2022)	Correlation of air pollution and prevalence of acute pulmonary embolism in Northern Thailand	Chiang Mai, Thailand	Retrospective cohort	696 patients without acute pulmonary embolisms	Acute Pulmonary Embolism	Adjusted RR for APE was significantly increased for PM10 in the second tertile (adjusted RR 1.76; 1.12-2.77), p = 0.014
Morantes-Caballero, et. al., (2019)	Effects of air pollution on acute exacerbation of chronic obstructive pulmonary disease: A descriptive retrospective study (pol-AECOPD)	Bogotá, Colombia	Retrospective cohort	250 patients with COPD	Acute Exacerbation of Chronic obstructive pulmonary disease (AECOPD)	On the day of symptom onset, patients with Anthonisen I or II had 1.4 times higher PM2.5 values (>25 μg/m3) (OR 2.45, 95% CI [1.13–5.31], p=0.019). High PM2.5 levels were linked to increased expectoration, purulence, pleuritic pain, and the use of antibiotics and corticosteroids.
Yu, et. al., (2021)	Outdoor temperature as an independent risk factor for Acute pharyngitis incidence: A preliminary study	Shanghai, China	Retrospective cohort	8287 patients with acute pharyngitis	Acute pharyngitis	The monthly hospital visits for acute pharyngitis showed a negative correlation with temperature (r =

						0.558, 95% CI 0.746, 0.274) and relative humidity (r = 0.480, 95% CI 0.695, 0.137). A decrease of 1°C could cause an increase in hospital visits by 1.9. No significant correlation was found between acute pharyngitis cases and AQI (P = 0.051, 95% CI 0.005, 0.590). Temperature was identified as the independent risk factor for acute pharyngitis (coefficient = 1.906, P = 0.022).
He, et. al., (2023)	Short-term effects and economic burden of air pollutants on acute respiratory tract infections in children in Southwest China: A time-series study	Sichuan Province, China	Longitudinal	192,079 children	Acute lower respiratory tract infections (ALRI)	The effect estimates of $PM_{2.5}$, PM_{10}, SO_2, and NO_2 for pneumonia reached their maximum at lag4, lag010, lag010, and lag07, respectively, with relative risk (RR) values of 1.0064; 1.0004–1.0124, 1.0168; 1.0089–1.0248, 1.0278; 1.0157–1.0400), and 1.0378; 1.0072–1.0692).

The research suggests that exposure to high levels of sulfur dioxide can pose an immediate threat to life, particularly affecting the respiratory tract. However, other organs and systems can also be impacted when the gas enters the bloodstream. This highlights the need for further study to understand the effects of reactive compounds associated with airborne particulates, which can exacerbate lung inflammatory responses.

Although 12 recent studies were reviewed using various Medical Subject Headings terms and databases, there are some limitations to consider. It is possible that certain studies were not included, and the review was confined to English-language publications. Additionally, the screening of titles was done by only one author, which may have introduced some subjectivity. However, the evaluation of article quality by two independent reviewers may have mitigated the risk of including unqualified articles. It's important to note that this review did not include unpublished or incomplete data, and was limited to studies published within the last 5 years. To minimize the risk of overlooking important studies, we also examined the reference lists of included articles.

4. CONCLUSION

The current literature suggests clear evidence of a link between major pollutants (PM, NOx, Sox, and O3) and respiratory-related illnesses. However, inconclusive results may be attributed to varying sample sizes and geographic locations among studies. To confirm this positive association, additional research involving human subjects is necessary. It is worth noting that while most studies focus on particulate matter, specifically PM2.5 and PM10, there is a limited number of investigations into other pollutants. Therefore, exploring the potential relationship between SO, NO, and O3 and respiratory diseases is essential.

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