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Worsening quality of life in COPD patients exposed to PM2.5 pollution particles

Letícia Nardin Coimbra[1], Paola Armbruster de Araújo[1], Paulo Rogério Scordamaglio[2]

[1]Undergraduate Student – Medicine, University of Santo Amaro, Sao Paulo – SP – Brazil.
[2]Faculty Member – Medicine, University of Santo Amaro, Sao Paulo – SP - Brazil.

ABSTRACT

OBJECTIVE

This study aims to analyze therelationship between PM2.5 exposure and the quality of life in COPD patients.

METHOD

A systematic literature review was conducted across PubMed, Scopus, and MEDLINE, focusing on articles published between 2014 and 2024, with a low risk of bias. The research followed the PICO model, considering studies that linked PM2.5 exposureto deteriorating quality of life in COPD patients.

RESULTS

The review included 21 articles, highlighting that prolonged exposure to PM2.5 exacerbates COPD symptoms, accelerates disease progression, increases hospitalization rates, and worsens quality of life. Patients exposed to PM2.5 exhibited greater physical limitations, more frequent exacerbations, and a higher risk of mortality. Additionally, there was an impact on mental health, with increased levels of anxiety and depression.

CONCLUSION

PM2.5 exposure significantly affects the quality of life of COPD patients, deteriorating both physical and psychological aspects. Pollution control policies are crucial to minimize these impacts and enhance pulmonary health, ultimately reducing the incidence and severity of chronic lung diseases.

DESCRIPTORS

Quality of life, Air pollutants, Disease progression, Respiratory signs and symptoms, Respiratory tract diseases.

Corresponding Author:
Letícia Nardin Coimbra.
R. Prof. Eneas de Siqueira Neto, 340 - Jardim das Imbuias, Sao Paulo - SP, 04829-300.
E-mail: leticianardincoimbra@gmail.com.
ORCID ID: https://orcid.org/0009-0003-1607-7467.

DOI:

INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) is a leading cause of morbid- ity and mortality worldwide, characterized by chronic and progressive airflow obstruc- tion associated with inflammation in the airways[1]. Patients with COPD experience debilitating symptoms such as dyspnea, cough, and excessive mucus production, which profoundly affect their quality of life[2]. This condition can be exacerbated by various factors, with environmental aspects being widely studied and linked to COPD[3]. Among these, air pollution is particularly significant, and fine particulate matter (PM2.5), particles with an aerodynamic diameter of 2.5 micrometers or less, stands out for its ability to penetrate deeply into the lungs, reaching the alveolar surface and triggering inflammation[4].

COPD has a substantial impact on patients' quality of life, and recent studies suggest that prolonged exposure to PM2.5 particles, present in air pollution, not only exacerbates disease symptoms but also accelerates its progression, significantly worsening the quality of life of these patients[5].

Moreover, COPD patients who smoke are more vulnerable to PM2.5 exposure[6]. Smoking is a primary risk factor for the development and progression of COPD, and when combined with exposure to air pollutants, especially fine particles like PM2.5, airway inflammation intensifies[6]. Studies such as Li *et al*. (2018) demonstrate that cigarette smoke in combination with pollution accelerates the decline in lung function, increases the frequency of exacerbations, and leads to more hospitalizations[6]. This specific group of smoking patients experiences a faster worsening of symptoms, primarily due to chronic inflammation caused by inhaling these particles[6].

Studies like those by Li *et al*. (2018) and Zhang *et al*. (2018) indicate a clear relationship between prolonged PM2.5 exposure and increased hospitalizations, mortality, and comorbidities such as cardiovascular diseases in COPD[6,7] patients. Additionally, previous systematic reviews, such as that by Kim *et al*. (2015), have shown the association between air pollution and lung function deterioration, suggesting that continuous exposure to these pollutants negatively impacts both the physical and psychological health aspects of patients[8].

However, although systematic reviews have addressed the impact of air pollution on respiratory health, few specifically analyze the relationship between prolonged PM2.5 exposure and the quality of life in COPD patients. Furthermore, many of these earlier studies have methodological limitations, such as heterogeneity in evaluation criteria and outcome analysis. This systematic review aims to fill this gap in the literature by focusing specifically on the influence of PM2.5 particles on the quality of life of COPD patients, based on the most recent and rigorous evidence published between 2014 and 2024.

This systematic review seeks to explore the relationship between PM2.5 exposure and the quality of life of COPD patients, contributing to the development of more effective public policies for pollution control and clinical management of these patients. Additionally, this review will enable a more accurate assessment of the risk of bias and study quality, providing a solid foundation for future research.

METHODS

This systematic review was conducted using the PubMed, Scopus, and MED- LINE databases between 2014 and 2024, employing a specific search strategy. Articles in English, Portuguese, and Spanish were considered.

The research question followed the PICO model: "Does prolonged exposure to fine PM2.5 particles, compared to lower levels of PM2.5 exposure, worsen quality of life by increasing symptoms, hospitalizations, and negatively affecting mental health in COPD patients?" The population consisted of COPD patients; the intervention involved exposure to PM2.5 particles present in pollution; the comparison involved COPD patients exposed to pollution versus those exposed to lower levels of PM2.5; and the outcome focused on quality of life deterioration, including symptom exacerba- tion, hospitalizations, and mental health impacts.

The Boolean operator "AND" was used, combined with the following descriptors: "*COPD* AND *PM2.5* AND *Quality of Life*"; "*Air Pollution* AND *COPD* AND *Exacerbation*"; "*PM2.5* AND *Respiratory Health* AND *Chronic Disease*"; and "*Pollution* AND *Mental Health* AND *COPD*."

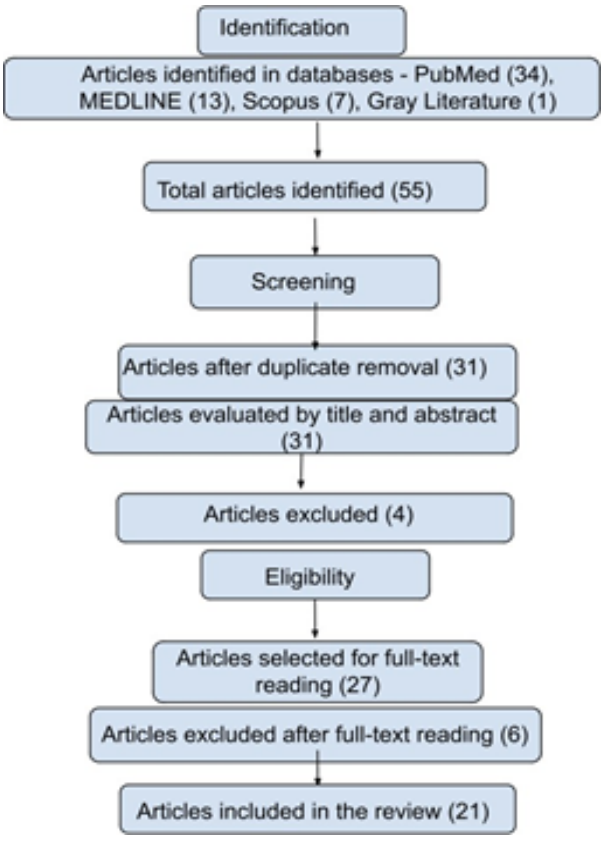
Inclusion criteria for the review were: articles published between 2014 and 2024, to ensure evidence reflected the latest scientific findings on COPD and air pollution; studies available in English, Portuguese, and Spanish; systematic reviews, meta-analyses, and studies using the PRISMA methodology, ensuring quality and ri- gor in data collection and analysis; studies addressing COPD and its complications, providing a deeper understanding of the pathology mechanisms and symptoms; studies exploring the relationship between PM2.5 exposure and changes in quality of life for COPD patients, such as symptom exacerbations and hospitalizations; and studies analyzing prolonged PM2.5 exposure and its outcomes.

Exclusion criteria were case report articles, as they do not provide robust and generalized data, limiting result applicability; articles lacking relevant conclusions on PM2.5 exposure in COPD patients; studies outside the defined time frame, as older articles may not reflect current environmental policies and air quality changes; and studies not directly investigating PM2.5 effects on COPD, avoiding distractions with other respiratory conditions.

Although the search strategy employed broadly relevant terms, it is important to note that some descriptors were not strictly aligned with DeCS (Descriptors in Health Sciences) guidelines. This may have led to the exclusion of relevant articles from the consulted databases, affecting the comprehensiveness of the presented re- sults. Future reviews should adopt strategies ensuring greater DeCS compliance to reduce biases and maximize literature coverage.

The study selection process is illustrated in Figure 1, which shows the identification of 55 studies initially. Of these, 21 were fully read, analyzed, and included in this review, as shown in Figure 1. The flowchart follows the steps of: 55 articles were identified (PubMed: 34, MEDLINE: 13, Scopus: 7, gray literature: 1). Screening: After removing duplicates, 31 articles remained, screened by title and abstract, excluding 4 articles by title. Elegibility: 27 articles were selected for full reading, with 6 articles excluded at this stage. Inclusion: 21 articles were included in the systematic review.

Figure 1 - PRISMA flowchart of the methodological steps for study selection used in this systematic review.



Source: Own authorship (2024).

The risk of bias of the articles was assessed based on the AMSTAR-2 method, as described in Table 1, indicating that most of them present a low risk of bias. The PRISMA guideline was used for the conduct and reporting of the review, thus enhancing the credibility of the studies.

Table 1 - Analysis of the risk of bias of the studies included in the present system- atic review using the PRISMA method.

Studies	Randomization	Intervention Deviation	Incomplete Data	Outcome Measurement	Selective Reporting	Overall Risk of Bias Conclusion
Global Initiative for Chronic Obstructive Lung Disease (GOLD) (2023)	Not applicable	Low risk	Low risk	Low risk	Low risk	Low risk
Agustí A., Hogg J. C. (2019)	Not applicable	Low risk	Low risk	Some concern	Low risk	Some concern
Mills, N. L., *et al.* (2015)	Not applicable	Some concern	Low risk	Some concern	Low risk	Some concern
WHO (2016)	Not applicable	Low risk	Low risk	Low risk	Low risk	Low risk
Guarnieri, M. & Balmes, J. R. (2014)	Not applicable	Low risk	Some concern	Low risk	Some concern	Some concern
Barnes, P. J. (2016)	Not applicable	Low risk	Low risk	Low risk	Low risk	Low risk
Li, R., *et al.* (2018)	Not applicable	Some concern	Low risk	Some concern	Some concern	Some concern
Wang, M., *et al.* (2016)	Not applicable	Low risk	Low risk	Some concern	Some concern	Some concern
Rojas- Rueda, D., *et al.* (2019)	Not applicable	Low risk	Low risk	Low risk	Low risk	Low risk
Zhang, Y., *et al.* (2018)	Not applicable	Some concern	Low risk	Some concern	Some concern	Some concern
Garcia-Ay merich, J., *et al.* (2017)	Not applicable	Low risk	Low risk	Low risk	Some concern	Some concern
WHO (2016)	Not applicable	Low risk	Low risk	Low risk	Low risk	Low risk
Pope CJ, *et al.* (2015)	Not applicable	Some concern	Low risk	Some concern	Some concern	Some concern
Cohen *et al.* (2017)	Not applicable	Some concern	Low risk	Low risk	Some concern	Some concern
Atkinson *et al.* (2015)	Not applicable	Some concern	Some concern	Some concern	Some concern	High risk
Burnett *et al.* (2018)	Not applicable	Some concern	Low risk	Low risk	Some concern	Some concern
Schrauf- nagel, D. E., *et al.* (2019)	Not applicable	Low risk	Low risk	Low risk	Low risk	Low risk
Gauderm an,W. J., *et al.* (2015)	Not applicable	Some concern	Low risk	Low risk	Some concern	Some concern
CAO, Y., *et al.* (2018)	Not applicable	Some concern	Low risk	Some concern	Some concern	Some concern
KIM, H., *et al.* (2015)	Not applicable	Some concern	Low risk	Some concern	Some concern	Some concern

Source: Own autorship (2024)

This systematic review was conducted in accordance with the PRISMA guidelines and registered in PROSPERO under registration number 596097. The protocol was submitted prior to the start of the study selection and analysis process.

RESULTS AND DISCUSSION

The results are presented in Table 2:

Table 2 - Results obtained from the analysis of the studies used for the preparation of this system- atic review, comparing the most relevant findings from each study.

Authors names and year	Article titles	Type of chemical composition	Related diseases	Key variable in the articles
Global Initiative for Chronic Obstructive Lung Disease (2023)	Global Strategy for the Diagnosis, Management, and Prevention of COPD	----------	Chronic Obstructive Pulmonary Disease (COPD)	Progressive air flow obstruction
Augustí A., Hogg J. C. (2019)	Update on the Pathogenesis of Chronic Obstructive Pulmonary Disease	----------	COPD	Debilitating symptoms, such as dyspnea, cough, and mucus production
Mills, N. L. *et al.* (2015)	Adverse Cardiovascular Effects of Air Pollution	Fine particles (PM2.5)	COPD, Cardiovascular diseases	Air pollution as an exacerbating factor of the condition
WHO (2016)	Ambient air pollution: A global assessment of exposure and burden of disease	PM2.5	COPD, Respiratory diseases	Fine particles penetrating deeply into the lungs

Guarnieri, M., & Balmes, J. R. (2014)	Outdoor air pollution and asthma	PM2.5	COPD, Asthma	Prolonged exposure to PM2.5 accelerates the progression of COPD
Barnes, P. J. (2016)	Inflammatory Mechanisms in Patients with Chronic Obstructive Pulmonary Disease	Toxic particles (cigarette smoke, environmental pollutants)	COPD	Abnormal inflammatory response of the lungs
UP Santos, MA Arbex, ALF Braga, RF Mizutani (2021)	Environmental air pollution: respiratory effects.	PM2.5, NO2, O3	COPD, Asthma, Pneumonia	Correlation between environmental pollution levels and the incidence/exacerbation of respiratory diseases
Li, R., Jiang, N., Liu, Q., *et al.* (2018)	Short-term and long-term effects of ambient PM2.5 on lung function: A systematic review and meta-analysis	PM2.5	COPD	Dose-dependent relationship between PM2.5 and COPD exacerbations
Wang, M., Belen R., Eeftens, M., *et al* (2016)	Long-term exposure to elemental constituents of particulate matter and mortality in Europe	PM2.5	COPD	Exposure to PM2.5 increases hospitalizations and mortality
Rojas-Rueda, D., Morales-Zamora, E., & Tainio, M. (2019)	Health impacts of urban transport policy measures: a quantitative assessment in five cities	PM2.5	COPD, Impact on Quality of Life	Significant decline in quality of life scores (St. George's Respiratory Questionaire)
Zhang, Y., Li, Q., Li, W., *et al.* (2018)	The association between air quality and the burden of COPD in urban areas	PM2.5	COPD	Increased mortality in COPD patients
Garcia-Aymerich, J., *et al.* (2017)	Associations between ambient air pollution and asthma and COPD exacerbations in Barcelona, Spain	PM2.5	COPD, Asthma	Pollution increases psychological stress, leading to social isolation and reduced well-being

Source: Own autorship (2024)

COPD is a chronic respiratory disease characterized by progressive airflow ob- struction[9]. The airflow limitation is generally caused by an abnormal inflammatory re- sponse in the lungs to the inhalation of toxic particles, such as cigarette smoke and environmental pollutants[10]. The main symptoms of COPD include shortness of breath, chronic cough, and sputum production, which directly affect the functional capacity and quality of life of patients[2].

Air pollution comprises a mixture of gases and suspended particles, among which PM2.5 consists of sulfates, nitrates, black carbon, heavy metals, and volatile organic compounds (VOCs), PM2.5 is considered the most harmful due to its small diameter, which allows it to penetrate deeply into the lungs[11]. Fine PM2.5 particles are associated with increased airway inflammation, higher mucus production, and a greater predisposition to respiratory infections, all of which are key factors in COPD exacerbation[6].

This systematic review analyzed 21 studies, including literature reviews, sys- tematic reviews, observational studies in urban areas, clinical guidelines, technical reports, cohort studies, quantitative policy assessment studies, global epidemiological studies, global evaluation reports, meta-analyses, and studies based on PRISMA methodology. The aggregated data from these studies reveal that prolonged PM2.5 exposure not only exacerbates COPD symptoms but also accelerates disease progression. Li *et al*. (2018) and Wang *et al*. (2016) conducted meta-analyses indicating a dose-dependent relationship between PM2.5 exposure and increased frequency of COPD exacerbations, hospitalizations, and consequently, reduced quality of life[6,12].

Although PM2.5 exposure in urban areas is a significant risk factor, it is essential to note that not all individuals living in large cities develop COPD[13]. Susceptibility to the disease is influenced by a combination of factors, including genetic predisposition, smoking, and other environmental conditions[13]. Reviewed studies suggest that patients living in urban areas with higher PM2.5 concentrations may have a greater risk of developing respiratory diseases, though this is not an exclusive determinant of COPD[13]. Smoking remains the most significant risk factor in the etiology of the disease[13].

PM2.5 particles are especially harmful to COPD patients due to their ability to cause chronic airway inflammation, increased oxidative stress, and direct lung tissue damage[3]. These particles penetrate deep into the lungs, triggering immune responses that worsen COPD symptoms, such as dyspnea and cough, leading to an increase in exacerbations.[8,14,15].

Studies like Rojas-Rueda *et al*. (2019) demonstrated, as highlighted in Table 2, that exposure to high PM2.5 levels is associated with a significant decline in quality-of-life scores, as measured by tools such as the St. George's Respiratory Questionnaire (SGRQ)[16].This questionnaire is widely used to assess the impact of COPD on patients' quality of life, covering aspects such as symptoms, activities, and psychosocial impact[9].

COPD patients exposed to higher PM2.5 concentrations tend to experience greater physical limitations, increased dyspnea, reduced capacity to perform daily activities, and a higher dependence on medical support[7]. Furthermore, studies like Zhang *et al*. (2018) showed that chronic PM2.5 exposure increases the mortality risk in COPD patients by up to 30%, as well as the risk of comorbidities such as cardio- vascular diseases, which also negatively impact patients' quality of life[7].

The deterioration in COPD patients' quality of life due to pollution is not limited to physical aspects, chronic PM2.5 exposure is associated with increased levels of anxiety and depression, as noted by Garcia-Aymerich *et al*. (2017)[17]. These mental disorders are particularly prevalent in patients living in urban areas with high pollution levels. Psychological stress, caused both by pollution and the chaotic urban environment, is a significant factor in worsening the mental health of these individuals, leading to social isolation and reduced overall well-being[17].

The diversity among studies, in terms of populations, exposure measurement methods, and outcome variables, may have hindered direct comparison of findings. However, the risk of bias is low.

FINAL CONSIDERATIONS

The systematic review of the literature highlighted that exposure to fine PM2.5 particles present in air pollution significantly impacts the quality of life of COPD patients. Prolonged exposure to these pollutants results in increased exacerbation, hospitalizations, mortality, and worsening respiratory symp-

toms, limiting functional capacity and negatively affecting the psychological well-being of these individuals, with additional impacts on mental health. The results emphasize the importance of air pollution control policies, along with effective management strategies, to minimize the adverse effects of pollution on the health of COPD patients.

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