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Impact of Air Pollution on Asthma: A Monocentric Prospective Study.

Impact de la pollution atmosphérique sur l'asthme : une étude prospective monocentrique.

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Résumé

Introduction : La pollution atmosphérique, en particulier les particules fines (PM10), a un impact profond sur l'asthme en exacerbant les symptômes, en augmentant la fréquence des crises et en réduisant considérablement la qualité de vie des personnes atteintes de cette maladie. Cette étude examine l'effet de l'exposition aux PM10 sur les patients asthmatiques à Alger. Ce projet a pour objectif essentiel d'étudier et de quantifier, au sein d'une population géographiquement définie, la commune de Sidi M'hamed, ville d'Alger, l'importance de l'impact sanitaire lié à la pollution atmosphérique urbaine, attribuable à l'exposition aux poussières, particules fines atmosphériques PM10, dont le diamètre est inférieur à 10 micromètres (μm).

Méthodes : Cette étude descriptive et longitudinale a évalué les résultats en matière de santé respiratoire chez des patients âgés de plus de 15 ans, qui se sont présentés aux services d'urgence avec des symptômes respiratoires aigus sur une période de deux ans. Le taux de pollution PM10 est mesuré à l'aide de la technique de radiométrie à jauge bêta.

Résultats : Au total, 183 477 patients ont consulté les services d'urgence au cours de la période d'étude, dont 20 606 cas (11,23 %) concernaient des problèmes respiratoires. Parmi ceux-ci, 5 874 étaient des patients asthmatiques. L'exposition aux PM10 s'est avérée déclencher des crises d'asthme, exacerber des symptômes tels que la toux, la respiration sifflante, la dyspnée et les douleurs thoraciques, et augmenter la demande de soins d'urgence et d'hospitalisation. Les plaintes les plus fréquentes étaient la toux (65,4 %), la rhinite (19,74 %) et les maux de gorge (19,1 %). L'étude a attribué 379 visites à l'hôpital et des consultations extra-hospitalières supplémentaires à l'exposition aux PM10, représentant respectivement 3,4 % et 4,5 % de tous les événements de santé observés.

Conclusion : La pollution atmosphérique est le principal risque environnemental pour la santé dans le monde. Chez les personnes asthmatiques, l'exposition aux PM10 est un déclencheur significatif des crises, de l'aggravation des symptômes et d'une utilisation accrue des services de santé, y compris les visites aux urgences et les hospitalisations.

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Mots clés : Pollution de l'air, Effet des PM10, impact sur la santé, Asthme, Symptômes respiratoires aigus.

Abstract

Introduction: Air pollution, particularly fine particulate matter (PM10), has a profound impact on asthma by exacerbating symptoms, increasing the frequency of attacks, and significantly reducing the quality of life for individuals with the condition. This study examines the effect of PM10 exposure on asthma patients in Algiers. The main objective of this project is to study and quantify, within a geographically defined population, the municipality of Sidi M'hamed city of Algiers, the importance of the health impact related to urban air pollution, attributable to dust exposure, atmospheric fine particles PM10, whose diameter is less than 10 micrometers, μm .

Methods: This descriptive, longitudinal study evaluated respiratory health outcomes in patients aged over 15 years who presented to emergency departments with acute respiratory symptoms over a two-year period. the pollution rate PM10 is measured by the beta gauge radiometry technique.

Results: A total of 183,477 patients sought care at the emergency departments during the study period, with 20,606 cases (11.23%) involving respiratory issues. Among these, 5,874 were asthma patients. Exposure to PM10 was found to trigger asthma attacks,

exacerbate symptoms such as coughing, wheezing, dyspnea, and chest pain, and increase the demand for emergency care and hospitalization. The most common complaints were cough (65.4%), rhinitis (19.74%), and sore throat (19.1%). The study attributed 379 hospital visits and additional extra-hospital consultations to PM10 exposure, accounting for 3.4% and 4.5% of all observed health events, respectively.

Conclusion: Air pollution is the world's leading environmental health risk. In individuals with asthma, PM10 exposure is a significant trigger for attacks, symptom aggravation, and increased healthcare utilization, including emergency visits and hospitalizations.

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keywords: Air Pollution, the effect of PM10, health impact, Asthma, Acute Respiratory Symptoms.

Introduction

Until recently, air pollution was recognized as a significant risk factor primarily for populations in industrialized countries. However, air quality monitoring data from the Algerian National Institute of Public Health indicates that in Algiers, the average daily PM10 levels decreased from 61 $\mu\text{g}/\text{m}^3$ to 42 $\mu\text{g}/\text{m}^3$ between 2001 and 2006[1-3]. The granulometric distribution of PM10 reveals a predominance of fine particles: the PM2.5 alveolar fraction accounts for 48% of PM10, while the PM1 fraction—which is irreversibly deposited in alveolar pockets—represents more than one-third of PM10 and approximately two-thirds of PM2.5[4].

The Algerian air quality standards for fine particles set a quality objective of 50 $\mu\text{g}/\text{m}^3$ and a limit value of 80 $\mu\text{g}/\text{m}^3$ for PM10 [5]. In comparison, the U.S. Clean Air Act, regulated by the U.S. Environmental Protection Agency (EPA), establishes a limit of 150 $\mu\text{g}/\text{m}^3$ for PM10 [6].

Globally, fine particles contribute significantly to health risks. According to the World Health Organization (WHO),

fine particulate matter was responsible for 3.7 million deaths worldwide in 2012. For PM10, WHO recommends a limit of 20 $\mu\text{g}/\text{m}^3$, which has been substantially exceeded in numerous metropolitan areas [7]. Fine particles are now considered a major indicator of urban air quality [8,9].

Air pollution has been linked to a broad spectrum of health issues, requiring both ambulatory and hospital care [10,11]. Studies from countries such as Switzerland, Sweden, China, and Mexico have shown that respiratory and allergic symptoms increase with greater exposure to air pollutants, even at low concentrations [12,13].

In Algeria, data from the National Report on the State and Future of the Environment (RNE), published by the Ministry of Territorial and Environmental Planning, reveals that 10 to 12 million inhabitants annually consult for acute episodes of respiratory diseases. Respiratory illnesses account for 4.5% of environmental morbidity in Algeria [14,15].

Methods

1. Type of Study

This is a **descriptive longitudinal study** assessing the association between a time series of air pollution measurements and health outcomes. The study involves all patients presenting to emergency departments with acute respiratory symptoms.

2. Population

The study population includes individuals aged over 15 years, residing near the air pollution sensor for at least three months, and seeking care at the emergency department for respiratory symptoms. Patients could directly visit the hospital, especially in cases of nocturnal asthma attacks, either after receiving first aid or without prior medical consultation. It is a prospective and descriptive study involving all patients over 15 years of age who would present to the emergency room at CHU Mustapha for acute respiratory symptoms: cough, dyspnea, cyanosis, chest pain, and respiratory arrest. In practice, the aim is to study the association between a time series of pollutant measurements and a time series of health data. Here, the observation unit is the time unit corresponding to the daily data collection. The health indicator characterizes a group of people residing in Sidi M'hamed, Algiers. The exposure indicator obtained from data collected by a sensor with a high-volume sampler that characterizes the exposure of the population as a whole. Estimated Annual Patients: Initially estimated at 121,904, based on a pre-survey done beforehand, the final figure was found to be 91,738.5 patients consultants for acute respiratory symptomatology.

The recruitment of patients is done at the medical-surgical emergency rooms of CHU Mustapha, the consultants for acute respiratory symptomatology, asthma will receive particular attention. The patients were residents in the district where the sensor is installed

Inclusion Criteria:

- Patients presenting with acute respiratory symptoms, including cough, dyspnea, wheezing, chest pain, or respiratory arrest.

Exclusion Criteria:

- Patients under the age of 15.
- Patients with acute respiratory failure secondary to trauma.
- Patients with known heart disease.
- Patients with end-stage renal failure.
- Patients with respiratory conditions of neoplastic origin or caused by other known diseases.

3. Study Setting

Air quality data was collected using a β -measuring device installed on the roof of a building, located 15 meters above ground level. The location provides optimal natural ventilation and is not influenced by local urban pollution sources (e.g., automotive or industrial emissions).

- **Particulate Matter Measurement:** PM10 levels were measured using the beta gauge radiometry technique, which determines beta radiation absorption. This method is independent of particle composition.

- **Device Configuration :**

- The device includes a carbon-14 source that alternates between two positions: out of the duct (in suction or standby mode) and in front of the Geiger-Müller detector.
- A Geiger-Müller detector captures beta radiation downstream of a filter tape, which collects airborne particles.
- The sensor serves as a background pollution indicator, unaffected by localized automotive or industrial pollution.

4. Methods Used

This study focuses on health impact assessment (HIA), calculated by estimating the number of cases attributable to the short-term effects of air pollution. The HIA evaluates health outcomes resulting from

PM10 exposure, based on established health data and pollutant measurements.

The method applied in this work is that used in the Air & Health Monitoring Program—9 cities (PSAS-9) of phase I [14] and II [15],

The proportion of cases attributable to short-term effects of air pollution is calculated from the exposure/risk relationship using the following formula:

$AP = f (RR-1) / (1+f (RR-1))$ where AP is the proportion of attributable cases, RR is the relative risk derived from the exposure-risk relationship to a reference exposure level; this relationship is linear with no threshold; and f: the prevalence of exposure.

As the duration of the study period did not allow for the construction of a dose-response curve from the collected data, we had to use a dose-response curve already

validated using an indicator of pollution and epidemiological indicators similar to those used in Algiers. The WHO curve was chosen [16].

From the relationship established by the WHO, we retained a RR of 1.0324, a confidence interval [95% CI, 1.019-1.046]. Such a method is only applicable when the relationship is considered causal, which is now accepted in the case of air pollution [17]. The methodology incorporates the following steps:

- Analysis of time series data linking PM10 levels to acute respiratory symptoms.
- Inclusion of all eligible patients presenting with symptoms such as cough, dyspnea, wheezing, chest pain, and respiratory distress.
- Calculation of health impacts based on previous studies and international benchmarks (e.g., WHO guidelines) [18, 19].

Results

1. Description of the Study Population

The study included 183,477 subjects who consulted at the UMC level over two consecutive years. Of these, 20,606 patients (11.23%) presented with respiratory diseases, including 5,874 asthmatic patients.

1.1 Frequency of Asthmatics by Age

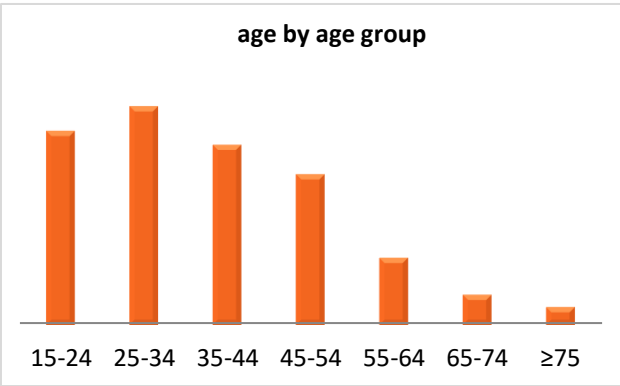


Figure 01: Frequency of asthmatic patients by age.

The majority of asthmatic patients (48%) were aged between 25 and 35 years, as shown in (Figure 01).

1.2 Incidence of Asthma by Sex

The incidence of asthma by sex is presented in (Figure 02), illustrating the gender distribution of asthmatic patients.

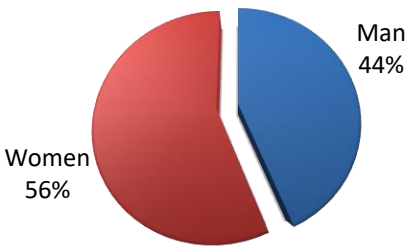


Figure 02: Incidence of asthma by sex.

1.3 Frequency by Symptoms

The main reasons for consultation among asthmatic patients are shown in Table 1. Respiratory difficulties were the most common, accounting for 81.64%, followed by wheezing (77.53%) and coughing (32.07%).

Table 01: Incidence of asthma by symptoms.

Reason for Consultation	Frequency	% (Percentage)
Cough	1,884	32.07
Wheezing	4,554	77.53
Chest pain	671	11.41
Difficulty breathing	4,796	81.64
Nasal flow/obstruction	1,162	19.76

1.4 Incidence by Time of Day

Asthmatics consulted the emergency department most frequently during the evening (39.43%), followed by the morning (37.86%) and afternoon (22.71%), as shown in (Table 02).

Table 02: Distribution of consultations by time of day.

Consultation Time	Frequency	% (Percentage)
Morning	2,201	37.86
Afternoon	1,320	22.71
Evening	2,292	39.43
Total	5,813	100

Patients with regular asthma follow-ups were more likely to consult in the morning (43.76%), while 18.11% of non-regular follow-up patients visited during the night.

1.5 Frequency by Severity

The severity of asthma attacks and the duration of monitoring are summarized in Table 03. Moderate asthma attacks, requiring an average observation time of 30 minutes, were the most common (48.5%).

Table 03: Incidence of asthma severity and observation time.

Observation Time (Minutes)	Frequency	% (Percentage)
15	962	16.5
30	2,820	48.5
60	1,953	33.6
120	69	1.4
Total	5,804	100

1.6 Seasonal Trends in Asthma Incidence

Asthmatic consultations peaked in January (13.52%) and decreased significantly in July (5%), as shown in Figure 3.

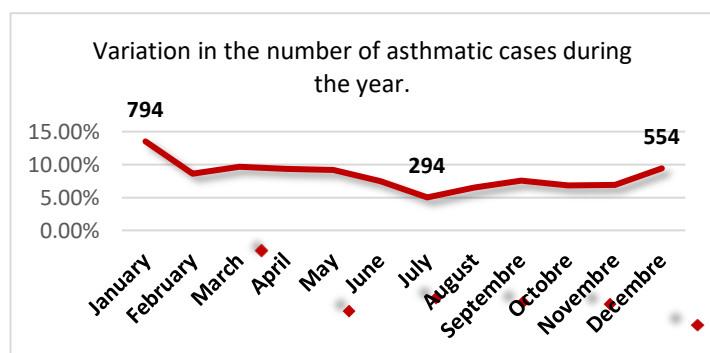


Figure 03: Seasonal trends in asthmatic consultations during the year.

1.7 The functional spirometric characteristics of asthma patients

Tableau 04: Result of the spirometries.

EFR	N	%
Obstructif	24	8,16
Restrictif	91	30,95
Mixte	30	10,20
Normal	149	50,68
TOTAL	294	100

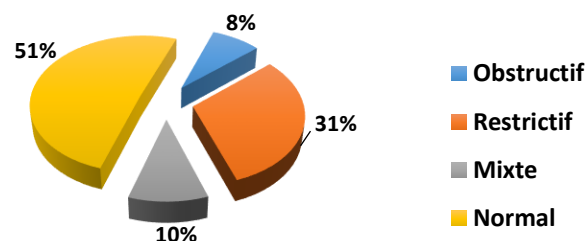


Figure 04: Result of the spirometries.

We have practice 334 spirometries were performed on patients with respiratory signs, 50% of the spirometries were normal, 30.95% of the patients had a restrictive syndrome.

2. Pollution Level Data

Daily PM10 levels ranged from 30 to less than 80 $\mu\text{g}/\text{m}^3$ for 214 days (59% of the study period). PM10 levels exceeded the quality target of 50 $\mu\text{g}/\text{m}^3$ on 46% of the days (164 days) (20. 21). Exposure levels above 80 $\mu\text{g}/\text{m}^3$, the Algerian limit value, were recorded on 58 days (16%). The average daily PM10 level was 53 $\mu\text{g}/\text{m}^3$. Winter PM10 concentrations were lower than summer levels (Figure 05).

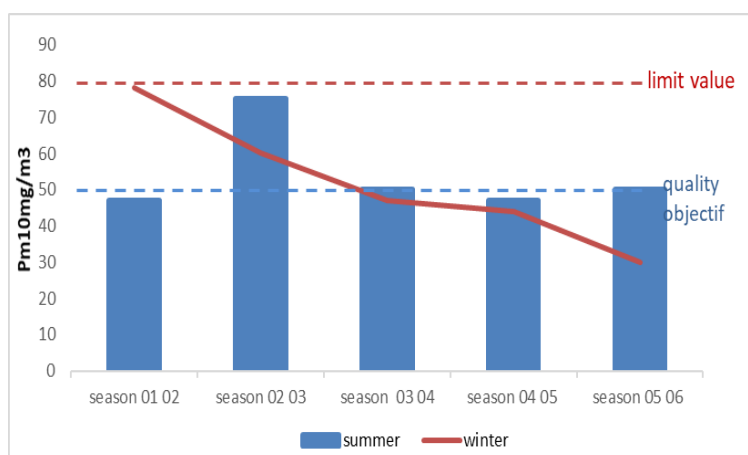


Figure 05: Annual and seasonal distribution of average PM10 levels ($\mu\text{g}/\text{m}^3$) in Algiers.

3. Impact of Air Pollution by PM10

The method applied in this work is that used in the Air & Health Monitoring Program–9 cities (PSAS-9) of phase I [14] and II [15], The

relationship between PM10 levels and the number of consultations is detailed in (Table 05). The overall impact of PM10 exposure was 3.4%, with 379 consultations attributable to PM10 exposure.

Table 05: Relationship between PM10 pollution levels and consultation rates.

Pollution Indicator (PM10, $\mu\text{g}/\text{m}^3$)	Number of Days	% of Days	Number of Attributable Cases	% of Cases
0–10	6	2	0.48	0.13
10–20	32	9	10.07	3
20–30	53	15	26.60	7
30–40	51	14	34.82	9
40–50	57	16	50.60	13
50–60	47	13	50.74	13
60–70	28	8	35.57	9
70–80	31	9	46.31	12
80–90	15	4	25.18	7
90–100	18	5	34.03	9
100–110	5	1	10.10	3
110–120	6	2	13.92	4
120–130	3	1	7.52	2
130–140	3	1	8.15	2
140–150	5	1	14.55	4
150–160	1	0	3.09	1
160–170	0	0	0.00	0
170–180	2	1	7.08	2

4. Combined Impact of Seasonal PM10 Levels and Health Outcomes

Seasonal variations in PM10 levels and their corresponding health impacts are summarized

in (Table 06). The distribution of daily exposure and its associated impact are shown in (Figure 06).

	Winter	Summer	Total Period
Moyenne	46	20	31
E.type	29,79	10,09	24,21
Percentile 5	18,00	5,65	7,00
Percentile 25	29,00	12,00	17,00
Percentile 50	37,00	19,50	25,00
Percentile 75	50,00	25,00	36,00
Percentile 90	86,00	33,70	52,60
Percentile 95	119,00	38,00	76,80
Max	157	56	157
Min	2	1	1

Table 6: Seasonal average PM10 levels and consultation data.

The total impact of exposure to PM10 was 3.4%, or 379 consultations attributable to exposure to PM10, this number was determined in relation to all observed respiratory health events. Levels below the limit value for exposure to PM10, namely 80

$\mu\text{g}/\text{m}^3$ [17] are responsible for 68% of the total impact, i.e. 209 consultations, representing 1.87% of all observed consultations. 58 days, or 16% of the days during the period of our study, had an exposure level above 80 $\mu\text{g}/\text{m}^3$, the Algerian limit value.

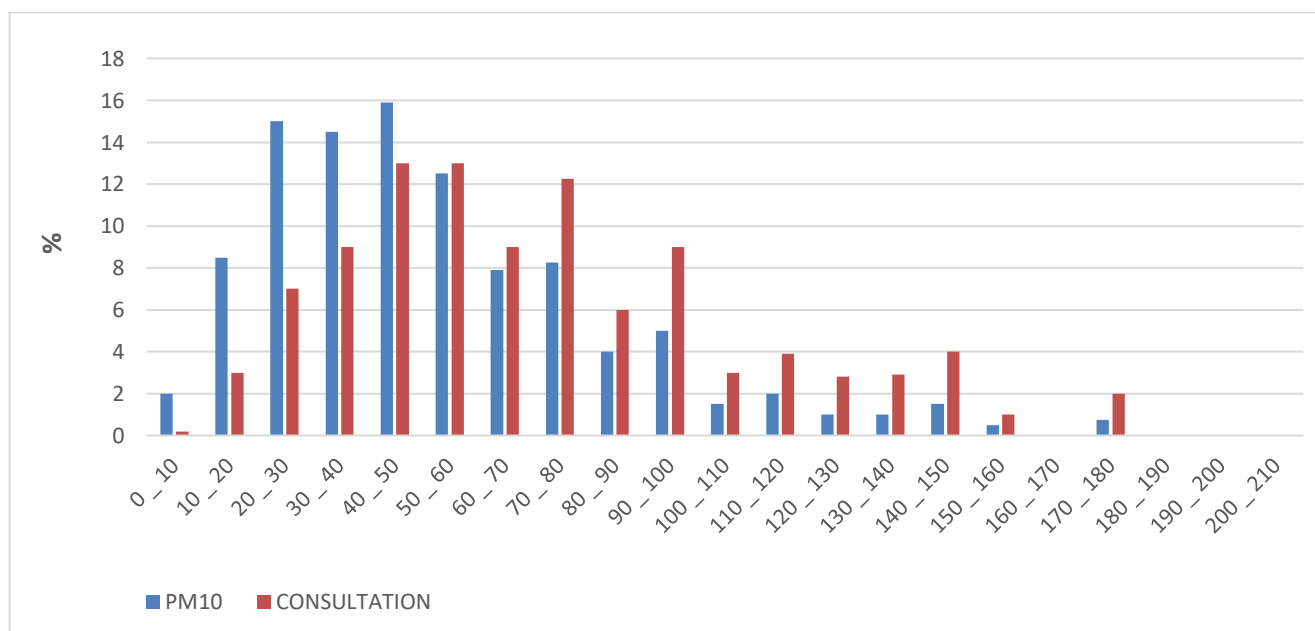


Figure 06: Relationship between PM10 levels, consultation rates, and health impacts.

Asthma symptoms were exacerbated during pollution spikes. Levels below 80 $\mu\text{g}/\text{m}^3$ [18] were responsible for 68% of the total

impact or 209 consultations, accounting for 1.87% of all observed consultations.

Symptoms and Consultation Patterns

- Main Symptoms: Dyspnea (81.64%), wheezing (77.53%), and cough (32.07%) were the most common complaints.
- Time of Day: Most visits occurred in the evening (39.43%), followed by the morning (37.86%).

PM10 Levels

- Average Daily Concentration: 53 $\mu\text{g}/\text{m}^3$.
- Exceedance of Quality Threshold (50 $\mu\text{g}/\text{m}^3$): Observed on 46% of study days[27].
- Exceedance of Algerian Limit (80 $\mu\text{g}/\text{m}^3$): Occurred on 16% of days.

Impact of PM10 Exposure

- Hospital Visits: 379 cases (3.4%) were attributable to PM10 exposure.
- Extra-Hospital Consultations: An estimated 4.5% were linked to PM10.

Discussion

Emergencies represent a significant proportion of unscheduled consultations. In our study, respiratory symptoms accounted for 11.23% of hospital visits, among which 5874 cases (3.2%) were due to asthma. The number of consultations for respiratory causes was significantly higher in winter than in summer, with an average of 46 consultations in winter compared to 20 in summer. The average daily number of consultations was 31.

The total impact of exposure to PM10 was 3.4%, or 379 consultations attributable to exposure to PM10, this number was determined in relation to all observed respiratory health events. Levels below the

limit value for exposure to PM10, namely 80 $\mu\text{g}/\text{m}^3$ [20] are responsible for 68% of the total impact, i.e. 209 consultations, representing 1.87% of all observed consultations.

164 days, or 46% of the days in our study period, had an exposure level above the quality objective (50 $\mu\text{g}/\text{m}^3$) [21].

58 days, or 16% of the days during the period of our study, had an exposure level above 80 $\mu\text{g}/\text{m}^3$, the Algerian limit value.

In our analysis, the average age of asthmatic patients was 37 years. Notably, 44% of the emergency consultants were patients monitored and treated for asthma, resulting in crises that were more manageable. In 65.16% of cases, the duration of observation during these visits was less than 30 minutes, indicating a less severe crisis among monitored patients. Studies suggest a distinct phenotype associated with asthma exacerbations triggered by air pollution in adults [22]. 50% of the spirometries were normal, 30.95% of the patients had a restrictive syndrome. This reframes the reliability of spirometers without calibration, and revives the interest in the peak flow meter.

There is a clear distinction between asthma attacks attributable to air pollution and an increase in PM 10.

The impact of PM10 pollution was also significant in our study. We found that 379 hospital visits were attributable to PM10 exposure, reflecting an impact of 3.4% of all observed health events. Evaluations of extra-hospital consultations showed a slightly higher impact, with 4.5% attributable to PM10 pollution [23]. These findings emphasize the burden of air pollution on asthma exacerbations in our population.

Comparison with Other Studies

A study conducted in Marseille with asthmatic patients reported an average annual PM10 level of 62 µg/m³, similar to the levels observed in our study. Researchers in Marseille observed a significant association between increased PM10 concentrations and a reduction in FEV₁ (Forced Expiratory Volume in 01 second), highlighting the detrimental effects of air pollution on respiratory function [24].

Similarly, a Swiss study on air pollution and lung diseases in adults noted a 40% increase in dyspnea prevalence and a 30% increase in bronchitis prevalence for a differential of 10 µg/m³ in PM10 concentrations [25]. Additionally, the prevalence of chronic cough increased by 2.5% for every 10 µg/m³ increase in annual PM10 levels [26]. These studies demonstrate the global impact of particulate matter on respiratory health, underscoring the urgent need for effective air quality management.

Comparison of PM10 Levels

A comparison of PM10 levels with European air quality standards shows that urban PM10 content in Algiers consistently exceeds recommended limits [27]. Numerous studies conducted worldwide, including in Taiwan, Thailand, China, Great Britain, Sweden, Switzerland, Netherlands, Finland, Czech Republic, Germany, United States, and Chile, reveal a strong association between respiratory symptoms and particulate matter pollution [15- 27,28]. These studies highlight that region exposed to industrial emissions, road traffic, or both, experience a higher prevalence of respiratory illnesses compared to less polluted areas.

Global Comparison of PM10 Rates

The WHO’s recommended PM10 limit of 20 µg/m³ has been substantially exceeded in many metropolises. For example, during pollution events in Geneva or Paris in March 2014, PM10 levels were much lower compared to highly polluted regions like India or Egypt [29]. (Table 07) presents a comparison of PM10 rates in Algiers and other cities with elevated pollution levels:

Table 07: Comparison of PM10 pollution rates in Algiers with other global cities.

City	PM10Levels (µg/m³)
Kolkata, India	220
Cairo, Egypt / Beijing, China	135
Algiers, Algeria	60
European Cities	20–40

Despite its lower PM10 levels compared to cities like Kolkata or Cairo, the rate in Algiers (60 µg/m³) still exceeds WHO standards and indicates a significant health risk.

Exposure to pollution is very heterogeneous. It varies considerably depending on the geographical location (proximity to pollution sources, urbanization), the time of day, the season and weather conditions. Current methods of exposure assessment (fixed measurement station data) do not always reflect the actual and personal exposure of individuals, who move and spend time in different environments. Integrating multiple factors into epidemiological models is a major challenge.

The use of portable individual sensors and high-resolution exposure modeling (based on artificial intelligence, geospatial data and traffic data) will allow a much more accurate and personalized assessment of pollutant exposure.

This will better correlate exposure levels with symptoms and biomarkers in individuals.

Limits and prospects for future research

Despite progress, research on PMs is limited by the difficulty of accurately measuring their composition, the imprecision of dispersal patterns and a still partial understanding of their mechanisms of action on health. Future perspectives rely on more advanced measurement technologies (sensors, satellites), artificial intelligence to improve predictions, and further research on the toxicology of particles based on their composition and size.

Conclusion

Air pollution is now the world's largest environmental health risk. Among people with asthma, exposure to PM10 can trigger attacks, worsen symptoms such as cough, wheezing, dyspnea, and chest pain, and increase the need for emergency care and hospitalization.

In Algeria, populations most vulnerable to air pollution's harmful effects on asthma include children, older adults, and pregnant women. However, further statistical analyses are necessary to precisely quantify the association between PM10 levels and asthma exacerbations.

This would provide a clearer understanding of the extent to which PM10 contributes to asthma-related health outcomes.

Protecting air quality is essential not only for public health but also for achieving sustainable development goals (SDGs). Reducing PM10 levels through policy interventions, improved urban planning, and industrial regulations is imperative for mitigating the impact of air pollution on respiratory diseases.

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