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City housing atmospheric pollutant impact on emergency visit for asthma: A classification and regression tree approach

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ABSTRACT

Introduction: Particulate matter, nitrogen dioxide (NO_2) and ozone are recognized as the three pollutants that most significantly affect human health. Asthma is a multifactorial disease. However, the place of residence has rarely been investigated. We compared the impact of air pollution, measured near patients' homes, on emergency department (ED) visits for asthma or trauma (controls) within the Provence-Alpes-Côte-d'Azur region.

Methods: Variables were selected using classification and regression trees on asthmatic and control population, 3–99 years, visiting ED from January 1 to December 31, 2013. Then in a nested case control study, randomization was based on the day of ED visit and on defined age groups. Pollution, meteorological, pollens and viral data measured that day were linked to the patient's ZIP code.

Results: A total of 794,884 visits were reported including 6250 for asthma and 278,192 for trauma. Factors associated with an excess risk of emergency visit for asthma included short-term exposure to NO_2, female gender, high viral load and a combination of low temperature and high humidity.

Conclusion: Short-term exposures to high NO_2 concentrations, as assessed close to the homes of the patients, were significantly associated with asthma-related ED visits in children and adults.

1. Introduction

Air pollution harms human health and the environment. Particulate matter (PM), nitrogen dioxide (NO_2) and ground-level ozone (O_3) are now generally recognized as the three pollutants that most significantly affect human health. In Europe, emissions of many air pollutants have decreased substantially in the past decade. However, a significant proportion of the population, especially in cities, still lives in areas where air quality standards set for maximum allowable pollutants are exceeded [1].

Pollutants have a direct irritant and inflammatory effect on neuro-receptors in the airways and bronchial epithelium [2]. NO2, O3 and PM induce airway inflammation and airway hyperresponsiveness (oxidative stress, immunology response and remodeling). According to the World Health Organization (WHO), in 2012, almost 3.7 million persons prematurely died as a result of air pollution in the world [3].

In France, the French Institute of Public Health Surveillance reported that $PM_{2.5}$ were estimated to cause more than 48,000 premature deaths per year, more than half occurring in cities larger than 100,000 inhabitants [4,5].

In recent decades, several epidemiological studies reported an association between short-term exposure to air pollution and adverse health effects, showing an increase in emergency room visits or hospital admissions for asthma as a result of increased pollution levels [6–13]. However, only a few epidemiological studies took into account confounding factors such as meteorological conditions, viral infections and pollen counts according to place of residence [11,14–17]. Moreover, no French study has evaluated the impact of short-term pollution exposure on asthmatic disease in the past decade, despite the lowering of the WHO-recommended threshold values.

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Abbreviations

CART	Classification And Regression Trees
CNIL	Commission Nationale de l'Informatique et des Libertés
ED	Emergency Department
EEDA	Electronic Emergency Department Abstracts
ICD	International Classification of Disease
ICD-10	International Classification of Disease, Revision 10
INSEE	National Institute of Statistics and Economic Surveys
NO_2	Nitrogen dioxide
O_3	Ozone
ORa	adjusted Odds Ratio
ORUPACA	Observatory of Provence-Alpes-Côte d'Azur region
PACA	Provence-Alpes-Cote-d'Azur
PM	Particulate matter
PM_{10}	Particulate matter with a diameter less than 10 μm
$PM_{2,5}$	Particulate matter with a diameter less than 2,5 μm
P	Probability values
WHO	World Health Organization

The mediterranean area, including Provence-Alpes-Côte-d'Azur (PACA; south-eastern France) region, has a dry and sunny weather that favors the generation of secondary pollutants. Its spatial heterogeneity is interesting as it includes coastal highly urbanized zones, major road traffic and high-density industrial places but also rural and mountainous ones with forest fires. Moreover, the air quality-monitoring network AIR PACA reported a total of 122 days when PM has exceeded the daily limit, while the national average is 35 days per year [18].

The aim of our study was to measure the impact of air pollution, assessed close to the homes of the patients, on asthma-related hospital visits to the emergency department (ED) within the PACA region in 2013, and to estimate the risks from pollution, meteorological conditions, pollen exposure and viral load.

2. Methods

2.1. Study area

The study was conducted in the PACA region of southeastern France (31,400 km^2; 4,937,445 inhabitants or 7.5% of the French population: National Institute of Statistics and Economic Surveys (INSEE 2013)).

This region is an intensively urbanized area with 9 out of 10 inhabitants residing in large urban and metropolitan areas. In 2013, it was the third most populated region of France.

Large urban areas, dense road, motorway networks and industrial zones make it the most significant area in France for air pollutant emissions.

2.2. Population under study

Electronic Emergency Department Abstracts (EEDA), recommended for every patient admitted to an ED in France, are directly available from the patients' computerized medical files. EEDAs are anonymously transmitted daily to "Santé Publique France" (a public health network) and included in the French syndromic surveillance system [19]. EEDAs report the date of the emergency room visit, age of patient, ZIP code of residence and final diagnosis using a national standardized thesaurus based on International Classification of Disease (ICD) codes validated by the French Society of Emergency Medicine. Since 2008, the ED Observatory of PACA region (ORU-PACA) has collected these data from EDs in the region.

From January 1 to December 31, 2013, EEDAs transmitted by EDs located in PACA were included in this study if they concerned a 3- to 99-year-old patient living in PACA.

We defined 3 age groups: 3- to 17-year-old, 18- to 49-year-old and 50- to 99-year-old. We excluded children under 3 years of age because it is more difficult to be sure about the diagnosis of asthma.

Each factor was recorded on the same day than the ED visit.

The controls were defined as patients consulting for trauma in ED. When the patient was discharge from the ED, the emergency physician had to code the final diagnosis using a national thesaurus of International Classification of Disease, Revision 10 (ICD-10) codes. Visits for an exacerbation of asthma (J45-J46) and for trauma (S00-T98) were defined according to this thesaurus.

This control group was chosen because they are a homogenous group whose attendance at the ED is less likely to be related to air pollution.

Patients' ZIP codes were used to link EEDA to the nearest ("as the crow flies") monitoring station for pollution, pollen and meteorological data.

The study was approved by the "Commission Nationale de l'Informatique et des Libertés" (CNIL), the French data protection authority (n°1,887,366).

This study was purely observational and consent of participants was not required because the research involved no intervention or contact with the patient. Only anonymous data were used.

2.3. Exposure data

2.3.1. Air pollution data

For each ZIP code, respectively, two primary air pollutants and one secondary pollutant were considered and measured in $\mu g/m^3$: daily average of particulate matter with a diameter less than 10 μm (PM_{10}), daily 1-hour maximum of NO_2, and daily 1-hour maximum of O_3.

The air quality-monitoring network AIR PACA, with 80 stations throughout the PACA region, took these measurements.

A spatial pollution surface model was created from the data for these three pollutants. Data were processed via the deterministic CHIMERE chemistry-transport model over a 4-km grid. Then a communal aggregation mesh was performed, using an average weight by population residing in each mesh.

2.3.2. Meteorological data

For each ZIP code, 4 daily weather indicators were recorded: average temperature (°C); air humidity (%); average wind speed (m/s) and rainfall (mm). These data were obtained from Météo-France (the French national meteorological company) and taken from a total of 237 monitoring stations. Each ZIP code was assigned to the nearest "as the crow flies" measuring station.

2.3.3. Pollen data

The choice of pollens was based upon two criteria: they had to be the most important pollen types causing sensitization and allergic symptoms in this geographic area and they had to be present in relatively high and significant concentrations.

For each ZIP code, the main taxa (*cupressaceae*, *birch*, *ash*, *poaceae* and *urticaceae*) were collected from 7 stationary pollen traps in PACA by the national network for aerobiological monitoring. Each ZIP code was linked to the nearest monitoring station.