Urban air pollution is still a public health problem in Paris

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By correlating data obtained from environmental indicators and health indicators over a five-year period, a system for measuring the effects of air pollution on health has been established and tested. Rises in air pollution levels do appear to be accompanied by increases in the relevant health problems.

In 1990 the Regional Council of Ile-de-France asked the Regional Health Observatory to evaluate the health risks of ambient air pollution. Among the many responsibilities of the Regional Council is regional transport policy. France is divided into 22 regions, one of which is the Ile-de-France, which includes Paris and has some 10 million inhabitants, about 20% of the country’s population.

The Regional Health Observatory was set up in 1975 to study health and social problems in the region, and is funded jointly by the state and the regional council. Its role is not to take decisions directly but to provide technical support for decision-making. For this purpose it conducts epidemiological surveys and studies on health and social services and facilities.

The regional officials were concerned that while there has been a considerable decline in pollution with sulfur dioxide and suspended particulate matter (to a large extent resulting from the development of nuclear energy in France), indicators for vehicle exhaust pollution have remained unchanged despite a reduction in unit emissions, owing to increased traffic.

A multidisciplinary working group was formed to design a study protocol. After analysing the relevant epidemiological studies published in international reviews from 1980 to 1991 (1), the group recommended making a time-series study on the short-term health effects of air pollution. This approach was chosen for the following reasons.

- Pollution levels in the Paris area are not very high and hardly differ from one location to another, so conventional epidemiological approaches were unlikely to detect areas of high risk.
- For the purposes of public health decision-making, the establishment of a continuously operating epidemiological surveillance system was recommended.
The main idea was to link health indicators with pollution indicators obtained through the AIRPARIF network, which is responsible for monitoring air quality in the Paris area. This had the advantages of making maximum use of the existing data and developing a common expertise among epidemiologists and environmentalists.

- Reliable data on mortality and the activities of the health care system could be obtained at reasonable cost.
- The Observatory had already had experience in using an approach like this as it had participated since 1984 in an influenza surveillance system, in conjunction with the Pasteur Institute in Paris (2).

This project, entitled “Health Risk Assessment of Urban Air Pollution”, brought together the National School of Public Health, the Pharmacy Faculty of the University of Paris V, the Hygiene Laboratory of the City of Paris, the Ile-de-France Regional Health Observatory, the AIRPARIF Association, and the National Public Health Centre. What follows is an outline of the project, and the initial results obtained and public health lessons learnt from it. Its purpose is to characterize and evaluate the short-term association between air pollution and the health of the population in the Paris area, and to assess the usefulness of establishing a public health surveillance system to deal with this problem.

**Methods**

A retrospective study was carried out for the period 1987–92, in order to do the following:

- define and select air pollution indicators using data collected by AIRPARIF, which monitors the following pollutants: black smoke, suspended particulate matter with a mean diameter of less than 13 microns, sulfur dioxide (SO₂), nitrogen dioxide (NO₂), and ozone (O₃);
- define relevant health indicators on the basis of home visits by physicians (800 000 by the SOS-Médecins group during the five years covered by the study), admissions to university hospitals, emergency paediatric consultations in hospitals, sick leave in large companies, and mortality in the study area;
- start an appropriate protocol for statistical analysis;
- evaluate the links between urban air pollution and these health indicators between 1987 and 1992 in the Paris area.

The protocol adopted for statistical analysis was designed for a project called “Air Pollution and Health: a European Approach”, supported by the European Union, which brings together researchers from 15 European cities. It takes the following factors into account:

- time variations for the indicators monitored, such as long-term (more than one year), annual, seasonal and weekly variations;
- non-cyclical variations, such as those due to hospital strikes and holiday periods;
- influenza epidemics and pollen counts;
- short-term weather effects (temperature, relative humidity);
- short-term effects of each of the air pollution indicators.
The degree of association between air pollution and health can be calculated by means of specialized regression models that can include all these parameters.

**Evolution of air pollution in the Paris conurbation**

During the last 30 years, sulfurous and particulate emissions at fixed combustion sites, such as domestic and institutional heating units and industrial sites, have fallen considerably. The decline is the result of several factors, especially the introduction of “special” zones, changes in local economic activity, increasing use of natural gas, and the development of nuclear energy for electricity production.

At the same time, however, motor vehicle emissions (with the exception of lead, which has gradually been removed from fuels) have increased. From 1985 to 1990 the emissions of nitrogen oxides, suspended particles and volatile organic compounds did not decrease. This situation reflects both an overall increase in road traffic and a change in types of vehicle, with increasing use of diesel fuel.

These qualitative and quantitative changes in emissions are reflected in mean ambient values recorded at monitoring stations in Paris as follows:

- For sulfur dioxide (SO$_2$), annual mean values have fallen by more than 85% in the Paris area in the last 35 years.
- For black smoke, annual values have declined by approximately 70% since 1960 at sites of background urban pollution not directly affected by motor traffic. From 1987 to 1992, pollution levels remained practically constant.
- Levels of nitrogen oxides (NO and NO$_2$) have only been measured since 1983, and the network of recording centres is still being established; the measurements made during the last decade have failed to indicate any clear trend.

- For ozone (O$_3$), the situation is similar; and mean summer values (April to September) do not appear to have changed significantly since 1983. It should also be noted that using urban measurement sites makes it difficult to assess changes in this pollution indicator at the regional level because of the interaction between ozone and NO.

As a result of these changes, there is growing interest in indicators of pollution caused by photo-oxidation (particularly of NO$_2$ and O$_3$) and their precursors mainly from vehicle emissions (nitrogen oxides and hydrocarbons).

**Main results of the retrospective study**

The results clearly demonstrate a statistically significant association between certain air pollution indicators and health status indicators (3). For each pollution indicator, depending on the distribution of daily values obtained in Ile-de-France, health risks are expressed in respect of three different situations:

- “medium” pollution, defined as the level reached or exceeded on 50% of the days of the year (percentile 50 or P50);
- “high” pollution, the level reached or exceeded on the 18 days of highest pollution in the year, i.e. 5% of the days of the year (P95);
“higher” pollution observed on five to eight days per year, depending on the indicators and years concerned. This situation is defined as an increase of 100 µg/m³ above base levels for each pollution indicator. The base level is defined as the maximum value obtained on the 18 days of lowest pollution, i.e. percentile 5 of the distribution of pollutant values (P5).

**Effects of sulfur dioxide levels**

Daily mean levels above base level for SO₂ (7 µg/m³), up to 23 µg/m³, 77 µg/m³ and 107 µg/m³ respectively are accompanied by the following rises in health parameters:

- 4%, 8% and 10% in death from cardiovascular causes;
- 6%, 12% and 14% in hospital admissions of children for asthma and 5%, 10% and 11% for ischaemic heart disease;
- 4%, 17% and 25% in home visits for asthma and 2%, 10% and 15% for headaches;
- 9%, 19% and 22% in sick leave for respiratory disorders.

**Effects of black smoke levels**

Daily mean levels above base level for black smoke (11 µg/m³), up to 26 µg/m³, 74 µg/m³ and 111 µg/m³ respectively, are accompanied by increases as follows:

- 2%, 5% and 6% in deaths from cardiovascular causes;
- 2%, 5% and 10% in hospital admissions for respiratory and cardiovascular disorders;
- 4%, 18% and 30% in home visits for asthma and 6%, 14% and 17% for headaches.

**Effects of nitrogen dioxide levels**

There is a clear link between nitrogen dioxide (NO₂) – essentially from road traffic – and the majority of health indicators. Daily mean levels above base level for NO₂ (22 µg/m³), up to 43 µg/m³ (P50), 78 µg/m³ (P95) and 122 µg/m³ (base level + 100 µg/m³) respectively, are accompanied by increases as follows:

- 3%, 9% and 17% in hospital admissions for asthma;
- 6%, 11% and 15% in home visits for disorders of the lower respiratory tract;
- 10%, 32% and 63% in home visits for asthma;
- 8%, 16% and 22% in home visits for headaches;
- 7%, 14% and 20% in sick leave for respiratory disorders.

**Effects of ozone levels**

Daily mean levels above base level for O₃ (3 µg/m³), up to 20 µg/m³, 81 µg/m³ and 103 µg/m³ respectively, are accompanied by the following increases:

- 1%, 5% and 6% in mortality from all causes other than accidents;
- 3%, 15% and 19% in hospital admissions of the elderly for chronic respiratory disorders;
- 12%, 22% and 24% in home visits for respiratory disorders in children;
- 11%, 19% and 21% in eye disorders.

Depending on the pollution and health indicators involved, the time-lag between increases in pollutant levels and health effects varies on average from less than a day to three days.
Significance of these findings

The historic episodes of pollution that occurred in the 1950s were known for their major effect on mortality, and the findings above suggest that urban air pollution continues to be associated with increased health risks. If the rises in health-related activities are really attributable to pollution, this means that the health effects of air pollution occur at levels of concentration below the limit values currently in force (4). It also means that the relation between air pollution and health is one with no threshold: any increase in pollution represents an increase in health risks.

It is therefore important to determine whether the statistical relationships observed are causal in nature. For practical reasons, the AIRPARIF network, like other air quality surveillance networks, does not measure all the pollutants contained in the complex mixture that is characteristic of urban air pollution, and the pollutants measured are seen as markers of overall air pollution. Thus the results should be interpreted as a whole rather than pollutant by pollutant.

There are several arguments to support the view that these findings show that there is a short-term causal effect of air pollution on health:

- The lengthy period of observation makes it possible to take into account long-term confounding factors.
- The method of analysis used makes it possible to take into account numerous other factors such as temperature, influenza and pollen.
- The time lags observed between rises in pollution and rises in health problems and activities are compatible with available experimental data.

- The results of this study are consistent with the existing information on this subject. They are particularly convincing in view of the fact that the relationships observed are more marked in the case of certain vulnerable population groups (children, the elderly, those with chronic diseases).
- No statistical relationship has been shown (using the same method of analysis) between air pollution and a priori unrelated disorders (e.g. winter pollution and renal colic).
- The relationships observed are consistent with those reported in other recent studies published in international scientific journals.
- The results are also confirmed by the preliminary results obtained in some of the 15 European cities currently using the same protocol.

Nevertheless, there are also some points which call for caution:

- This is an ecological study, in which exposure is not measured in the individuals concerned. It is assumed in this type of study that on average the entire population is exposed to the same levels of pollution. It is recognized in epidemiology that the level of proof obtained with this type of protocol is not as high as it would be with individual case studies. For this reason a cohort study of asthmatics (adults and children) receiving hospital treatment has been started, so that the results can be compared.

The relation between air pollution and health is one with no threshold: any increase in pollution represents an increase in health risks.
While there is no doubt as to the representative nature of the mortality data, that of the morbidity data has yet to be evaluated.

Quantitatively, at individual level, the relationships observed are weak (relative risks <2), so that the possibility cannot be totally excluded that they are the result of unknown confounding factors not taken into account.

The purpose of the study was to analyse the effects of air pollution in terms of health risks for the Île-de-France population. In spite of a decline in certain pollution indices over the last 30 years, it appears that the concentrations observed during the period 1987–92 are associated with health problems. This association has been demonstrated at pollution levels below European and WHO reference values and thus may serve to reopen the debate on the adequacy of current health protection standards.

Since the figures indicate effects that are low in terms of individual risk but affect a population of more than 6 million for the Paris area, they raise the question of whether to reinforce pollution control measures. Other medium-term and long-term prevention activities may also be called for, such as public information when high levels are recorded for particular pollutants, and the application of new technologies, especially with respect to vehicle emissions.

These results, like those already published internationally, make it reasonable to state today that urban air pollution is still a public health problem. They show the need for a reduction in background air pollution in urban areas, which would also make it possible to reduce the frequency of pollution episodes resulting from unfavourable weather conditions. They also show the need for prevention and information activities in the case of pollution by ozone and nitrogen dioxide.

Towards an epidemiological surveillance system

The results of the study have led to proposals for a permanent public health air pollution surveillance system in Île-de-France to provide an information base for pollution management. This would help to dispel many of the current uncertainties about the health effects of air pollution. Such a system should make it possible to do the following:

- conduct ongoing evaluation of the health risks of background pollution levels and high pollution episodes;
- verify pollutant monitoring for public health purposes and guide its evolution;
- evaluate control measures and prevention activities;
- propose local health protection reference values;
- provide the components needed to design an air quality information system which includes health implications, with easy access for the general public, professionals and decision-makers.

Ultimately, the goal is to include measurable health considerations in policies aimed at reducing air pollution, and provide guidance in implementing preventive measures.

For the last three years, the study has brought together expertise from hitherto disparate areas in a joint project, with very active participation by the various members of the network, such as managers, environmentalists, physicians and epidemiologists. The first phase has shown that this approach is workable and useful. It will serve as a pilot project for the National Public Health Centre,
recently set up in France to bring health surveillance of air pollution to all major French cities.

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References

Everyone cares about protecting the environment
A recent groundbreaking Gallup Survey found that public concern about environmental problems is uniformly high around the world – dispelling the myth that only rich countries can afford to care about these issues. ... Interestingly, the survey found little inclination toward global finger-pointing. When asked whether rich or poor countries were more responsible for global environmental harm, everyone accepted some share of the blame. Support for international cooperation to solve shared problems was also high.