HEALTH IMPACT OF PM_{10} AND OZONE IN 13 ITALIAN CITIES

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Abstract

Over the last few decades, the evidence on the adverse effects on health of air pollution has been mounting. A broad range of adverse health outcomes due to short- and long-term exposure to air pollutants, at levels usually experienced by urban populations throughout the world, are established.

This report estimates the health impact of PM_{10} and ozone on urban populations of 13 large Italian cities. To do so, concentration-response risk coefficients were derived from epidemiological studies, and 25 adverse health outcomes and different exposure scenarios were considered. Average PM_{10} levels for the years 2002–2004 ranged from 26.3 $\mu g/m^3$ to 61.1 $\mu g/m^3$. The health impact of air pollution in Italian cities is large: 8220 deaths a year, on average, are attributable to PM_{10} concentrations above 20 $\mu g/m^3$. This is 9% of the mortality for all causes (excluding accidents) in the population over 30 years of age; the impact on short-term mortality, again for PM_{10} above 20 $\mu g/m^3$, is 1372 deaths, which is 1.5% of the total mortality in the whole population. Hospital admissions attributable to PM_{10} are of a similar magnitude. Also, the impact of ozone at concentrations higher than 70 $\mu g/m^3$ amounts to 0.6% of all causes of mortality. Higher figures were obtained for the effects on heath that result in morbidity.

The magnitude of the health impact estimated for the 13 Italian cities underscores the need for urgent action to reduce the health burden of air pollution. Compliance with European Union legislation can result in substantial savings, in terms of ill health avoided. Also, local authorities, through policies that aim mainly to reduce emissions from urban transport and energy production, can achieve sizeable health gains.

Keywords

ENVIRONMENTAL EXPOSURE; ENVIRONMENTAL MONITORING;
AIR POLLUTANTS – adverse effects; OZONE – adverse effects; RISK ASSESSMENT;
HEALTH STATUS INDICATORS; URBAN HEALTH; ITALY.

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Executive Summary

Over the last few decades, a growing body of evidence points to ambient air pollution as a cause of adverse effects on health. The vast scientific literature on the subject includes epidemiological, clinical and toxicological studies, and research has systematically documented a broad range of adverse health outcomes, ranging from respiratory symptoms to mortality from cardiopulmonary diseases and lung cancer. These outcomes result from both short- and long-term exposure to air pollutants, at levels usually experienced by urban populations throughout the world, in both developed and developing countries. In support of the plausibility of the observed associations, clinical and toxicological studies have provided significant information on pollutant specific effects and possible mechanisms for these effects. Research continues to progress and, though many questions still need answers, air pollution is one of the most developed subjects today in the field of environmental health.

Thanks to this solid evidence and to the good quality of ambient monitoring networks, which provide daily measurements of air pollutants, it is now possible to reliably assess the health impact of air pollution on urban populations. Studies like the present one use existing evidence to estimate the proportion of mortality and morbidity (cases attributable to air pollution) that could be prevented if average ambient concentrations were reduced to target concentrations.

In 1998, the WHO Regional Office for Europe first estimated the health impact of particulate matter with an aerodynamic diameter smaller than 10 microns (PM_{10}) on the population of the eight largest Italian cities. Given the magnitude of the impact in this assessment, the continuing scientific and policy debate and the growing evidence on the adverse effects on health of air pollution, the Italian Agency for Environmental Protection and Technical Services commissioned the WHO Regional Office for Europe to update of the first study.

This new study does the following.

- It updates the results to 13 Italian cities with populations of more than 200 000 inhabitants – Turin, Genoa, Milan, Trieste, Padua, Venice-Mestre, Verona, Bologna, Florence, Rome, Naples, Catania, Palermo – with an overall population of about 9 million people, 16% of the total national population.
- It uses health data from national statistical sources and from consolidated international literature.
- It considers pollutant data for the triennium 2002–2004.
- It estimates the exposure of urban populations to PM_{10}, based on data from traffic and background monitoring stations.
- It broadens the analysis to include ozone and estimates its separate health impact.
- It uses concentration–response risk coefficients from epidemiological studies updated to November 2005.
- It considers 25 adverse health outcomes, including cause-specific chronic and acute causes of mortality and several morbidity end-points.
- It describes the health impact of PM_{10} and ozone, in terms of deaths and cases attributable to these air pollutants and in terms of years of life lost that could be prevented under different alternative scenarios: the reduction of the average

concentration of PM_{10} to 20 µg/m^3, 30 µg/m^3 and 40 µg/m^3 or by 10% in every city; and the reduction of the concentration of ozone to 70 µg/m^3.

- It presents detailed results by age groups and sex.

Air pollution has a large impact on health in Italian cities. In the period 2002–2004, average yearly PM_{10} concentrations range from 26.3 µg/m^3 (Trieste) to 61.1 µg/m^3 (Verona), with a population weighted mean of 45.3 µg/m^3. 8220 deaths a year, on average, were attributed to PM_{10} concentrations above 20 µg/m^3. This is 9% of the mortality for all causes, excluding accidents, in the population older than 30 years of age. This figure is estimated by considering the long-term effects on mortality. Considering the short-term effects on mortality (within a week after an exposure), the impact of PM_{10} above 20 µg/m^3 was 1372 deaths or 1.5% of the total mortality in the whole population. Concentrations measured in Italian cities during the years 2002–2004 were higher than the European average concentration, and so were, proportionately, the health impacts.

The greater detail now available in the literature on the effects of particulate matter on mortality allows a breakdown, by cause of death, in both the long and short term. Long-term impact on mortality includes lung cancer (742 cases a year), infarction (2562 cases a year) and stroke (329 cases a year). Short-term impact on mortality includes cardiovascular diseases (843 cases a year) and respiratory diseases (186 cases a year).

Large numbers of cases attributable to these pollutants were estimated for other outcomes, including morbidity in children and adults (such as bronchitis, asthma and respiratory symptoms), hospital admissions for cardiac diseases and respiratory conditions, and ill health that results in restricted activity and in the loss of work days. For Italian cities, these impacts are sizeable, with estimates in line with those obtained in analogous impact assessments in Europe and the Americas.

Unlike the previous assessment, the present one includes the impact of ozone. Ozone is a pollutant of growing concern, especially in southern European countries. The concentrations observed are on the increase, and their adverse effects on health are being more firmly established. Using the SOMO35 indicator as the standard for concentrations, ozone was estimated to have a yearly impact of 516 deaths in Italian cities (0.6% of the total mortality), with a loss of 5944 years of life. This impact adds to that of particulate matter, because the two pollutants are uncorrelated and are used as independent indicators of air quality.

The health impact of particulate matter and ozone represent important public health issues. The burden of disease is great at the individual and family level, among adults and children, and includes premature death, and chronic and acute diseases, such as cancer, bronchitis, asthma and the prevalence of respiratory symptoms. The burden on society is also great: loss of life due to a significant reduction in life expectancy, and the loss of economic productivity due to mild and severe impairments. Finally, it is a great burden on health care systems, because of thousands of hospital admissions.

By itself, PM_{10} is considered a good measure of the complex mix of gaseous and dust pollutants that originate from fuel combustion in vehicles and power generators, and it remains the pollutant of choice for assessing the health impact of air pollution. Epidemiological evidence continues to grow, with new studies using PM_{10} as the exposure indicator for particulate matter, and most monitoring data are presently based on PM_{10} measurements. However, it is desirable to have systematic measures of the concentrations of finer particles, because the effects on health of particles with an aerodynamic diameter smaller than 2.5 microns, called $PM_{2.5}$, are presently well known, and fine particles can be more easily traced to emission sources: $PM_{2.5}$, for example, correlates more closely with motor vehicle traffic than does PM_{10}. It is not by chance that $PM_{2.5}$ has been routinely monitored in several European and North American countries in recent years.

The impacts estimated are likely to provide an incomplete picture of the total burden of disease. Other health end-points are also affected, but they are not included in the assessment, because the risks are not estimated reliably. Infant mortality, for example, is not included, due to the difficulties of extrapolating risks estimated in studies carried out in Latin America and Asia. Also, other health end-points are mild, difficult to measure and have positive, but unquantified risks.

The magnitude of the health impact of air pollution estimated for the 13 Italian cities of the present report underscores the need for urgent action to reduce the burden of disease in these cities and, likely, in many others. Compliance with European Union legislation results in substantial savings, by avoiding ill health, and it is important that the limits on PM_{10} introduced in Directive 1999/30/EC (European Union, 1999) are met and that they should not be relaxed.

Italy, however, is one of the European Union Member States where this may be a challenge. In 2005, in Italy, many of the major cities had reached the allowed 35 days in excess of 50 $\mu g/m^3$ of PM_{10} by the end of March. Also, only some cities are in compliance with the annual average of 40 $\mu g/m^3$ of PM_{10}, and none is in compliance with the average value of 20 $\mu g/m^3$ of PM_{10}, which is the limit to be reached in 2010.

Information on sources can be used to identify the most profitable areas of policy response. The data in the present report suggest that substantial gains can be achieved through policies aimed mainly at reducing emissions from two sources: urban transport and energy production. Emissions of PM_{10} from these sources are the main contributors to total primary emissions in Italian metropolitan areas.

Identifying specific policies for reducing concentrations is necessary. With regard to emissions of particulate matter, health gains can be obtained by reducing concentrations through different strategies. Since the association between air pollution and its adverse effects on health is linear and has no threshold, the effects of air pollution will decrease in proportion to the average concentration, for all health outcomes. So different interventions that produce the same yearly average will provide the same health benefits. In principle, this suggests that a variety of policy options are available. However, empirical data show that measures that reduce peak concentrations also reduce average concentrations (Cirillo, 2003). Thus, emissions from the main urban sources, notably motor vehicles, must be reduced substantially, through policies that aim to contain private motorized transport and promote public transport, cycling and walking. In Italian cities, special attention should also be paid to the contribution to air pollution of motorcycles, especially those with two-stroke engines.

Within the general policy goal of reducing emissions, attention should be given to local circumstances. In particular, PM_{10} concentrations observed in the present study were high in northern cities (50 $\mu g/m^3$), as compared with urban areas located in central (43 $\mu g/m^3$) and southern Italy (35 $\mu g/m^3$). These differences are likely to be due mainly to differences in transport, industrial activities, and heating-related emissions at the city level and at the regional level – together with climatic factors. For example the cities of the Po-Venetian Plain (Verona, Milan, and Padua) have high concentrations of PM_{10} (59 $\mu g/m^3$, annual average for the period 2002–2004) due to intense local urban traffic, intense regional traffic and intense industrial activities, combined with climatic conditions that limit the dispersion of pollution. Under these circumstances, action taken by one municipality to reduce, for example, emissions from motor vehicles is likely to have modest results. Instead policy initiatives at the regional level may be needed to achieve substantial gains in reducing concentrations of air pollutants and in improving health.

Similar considerations apply to ozone. Ozone contributes a considerable additional health impact, although its impact is smaller than the one for particulate matter. Repeated epidemiological studies have demonstrated that risks to health increase linearly with ozone concentration and are observed not only on days with ozone peaks, but are also observed on non-peak days. For this reason, as with particulate matter, strategies for reducing ozone levels should target not only peak days but should also target average concentrations. Given that precursors of ozone are produced mainly by combustion processes, preventive action, again, should target emissions from transport and, where relevant, industry.

Policies directed at the traffic sector are particularly appropriate for several other reasons. Apart from the importance of emissions of primary particulate matter by traffic, other emissions from road transport (such as resuspended road dust and wear of tires and brake linings) are the main source of the coarse fraction of particulate matter ($PM_{10–2.5}$). Finally, restrictions on private motor vehicle traffic would result in a number of health co-benefits through, for example, reduction of road accidents, of exposure to noise, of psychosocial effects and through the possible increase of walking and cycling. In the case of road accidents, the number of fatal injuries recorded among residents of the 13 Italian cities in 2001 is of the same order of magnitude as the short-term impact of PM_{10}. Indeed, methods that quantify the health impacts of broad policies, rather than individual risk factors (such as air pollution), are of growing interest in the fields of environment and health.