SHORT-TERM HEALTH EFFECTS OF PARTICULATE AIR POLLUTION WITH SPECIAL REFERENCE TO THE NEEDS OF SOUTHERN EUROPEAN COUNTRIES

Exposure to air pollution, especially from particulate matter, is generally accepted to be one of the most important public health problems in Europe and worldwide. The effects caused in the general population are associated with relatively small relative risks, but if the ubiquity of exposure is considered, the attributable number of events is large. Furthermore, there is evidence that the effects in sensitive population subgroups (such as the elderly, those with chronic diseases and children) are stronger. Within large European Union funded collaborative projects (such as the Air Pollution and Health: a European Approach - APHEA), effect modification by geographical characteristics has been investigated and it was found that in warmer countries, in locations where particles come from traffic and where the proportion of the elderly is greater, particle toxicity is increased. These characteristics are particularly relevant to Southern European locations. From other projects we know that meteorological, climatic, environmental and socioeconomic factors are effect modifiers of the effects of specific air pollutants. In this presentation we will show the evidence on the short-term health effects of particulate and gaseous air pollutants and emphasize particularly results concerning southern Europe and potential effect modifiers. The gaps in knowledge and the need to study air pollution in Southern European countries more extensively will be demonstrated. To conduct useful research, good quality air pollution and health data are needed.

Keywords: air pollution; ambient particles; effect modification; Southern Europe.

The effects of air pollution on health were recognized after severe air pollution episodes in Northern Europe and North America between 1900 and 1965, to which thousands of acute deaths have been attributed [1]. These events led to a reduction of air pollution levels through legislative and other measures. From about 1970 to 1990, the prevailing opinion among scientists and decision makers was that current air pollution levels did not have important adverse health effects. However, since roughly 1990, it became evident that the current, relatively lower, air pollution levels (mainly ambient particles) had adverse, short-term and long-term, health effects including an increase in mortality. The initial evidence originated from short-term exposure epidemiological studies [2,3]. As it accumulated, it had a considerable impact in standard setting and proposed guidelines for air pollutants by National (such as the U.S. Environmental Protection Agency) [4] and International (such as the World Health Organization and the European Commission) [5,6] organizations. As a result, in EU there is a requirement for frequent monitoring of specific air pollutants and a good spatial coverage leading to several well conducted and informative studies [7]. The problem of health effects from exposure to air pollutants is more important in southern and central-eastern EU and non-EU countries of Europe.
as the concentrations of pollutants have often been measured at higher levels and the particles mixtures have been found more toxic in warmer countries, either because of particular characteristics of the particles or due to larger population exposures [5,8-12]. However, in some countries there is still a lack of systematic measurements covering adequately the time and spatial scale.

The effects of air pollution on health are often conveniently classified as short-term and long-term although there is probably a continuum of effects in the time scale, which are not yet fully understood. By “short-term” effects we usually refer to the effects manifested in the same or the next few days (e.g. up to a week) after a specific exposure to an air pollutant or a mixture of air pollutants and, in recent studies, also to the effects over a period of about 30-40 days. By “long-term” effects we refer to effects resulting from a life-long exposure or, at least, one over a long period of several years.

This paper will emphasize the results of short-term studies.

SHORT-TERM EFFECTS OF PARTICULATE AIR POLLUTION ON HEALTH

Short-term effects are studied through, mainly, two epidemiological study designs:

1. Time series studies, which use aggregated data and the unit of aggregation is a time period, usually of a day. These data are often routinely collected and are available for long time periods. One advantage of the design is that there is no confounding by individual characteristics. However, there is potential confounding by variables that vary on daily basis (e.g., temperature).

2. Panel studies, which are based on a cohort followed intensively for a relatively short time. These studies often have daily individual data [13].

3. More recently, the case-crossover analysis is also used. In this approach, days with an event are compared to days without the event matched on important confounders. This approach requires smaller data availability and has a wider applicability [14].

During the last two to three decades a vast amount of research has accumulated on the short-term health effects of particulate matter (PM). PM metrics used in most studies are based on mass concentrations with size cut-offs (e.g., PM$_{10}$, PM$_{2.5}$, PM$_{1}$). Less research has focused on the sources and specific chemical characteristics of PM, although these have considerable significance because there is evidence that the toxicity of PM depends on their chemical-physical characteristics and, consequently, on their sources [5,15].

PM is deposited in various parts of the respiratory system mainly depending on their size. Mechanisms of toxicity have been described in the toxicological literature including inflammation and immunological responses. The outcomes assessed in epidemiological studies range from the least severe sub-clinical effects to moderate ones, like impaired pulmonary function, respiratory symptoms, excess medication use, restricted activity and visits to medical doctors and finally to more severe, like emergency room visits or hospital admissions and premature deaths [5].

Mortality outcomes

During the late 80’s and early 90’s several time-series studies produced evidence of short-term effects of exposure to PM on the daily number of deaths. Their results were put in a broader context and were consolidated with the initiation of large multi-city studies in Europe and the U.S. In 1993 the multi-city European Commission sponsored APHEA (“Air Pollution and Health: a European Approach”) project was initiated [16]. It included data from up to 30 European cities spanning across the continent. An increase of 10 μg m$^{-3}$ in PM$_{10}$ was found to be associated with a 0.6% increase in the total and respiratory daily number of deaths and a 0.8% increase in cardiovascular deaths [17]. When a longer time period after the exposure is considered (about 40 days) then the observed increase in total mortality is estimated to be 1.6%; in cardiovascular mortality 1.97% and in respiratory mortality 4.2%, indicating lagged effects, which are larger for respiratory deaths [18]. The NMMAPS (“National Mortality, Morbidity and Air Pollution Study”) in the U.S. reported consistent results [19].

The shape of the exposure-response relationship is important for public health assessment, as this reveals the possible existence of a safe level and the effect size at specific ranges of the pollutants concentrations. It has been found that the exposure-response is compatible with a straight line and there is no identifiable threshold within the range of concentrations observed in the European and North American cities [20].

The public health importance of the short-term mortality effects has often been questioned. The critics suggested that only the very frail individuals, who were going to die soon, could be affected by air pollution exposure. However, if this “harvesting” hypothesis were true, the observed increase in mortality would have been followed by a subsequent decrease of equal size. The use of analyses with distributed lag models gave evidence that this does not happen, i.e.,
for about 40 days after exposure, mortality remains elevated [21].

The city specific effect estimates of the above multi-city studies often displayed heterogeneity. Investigating the reasons for heterogeneity, effect modifiers were identified, within the context of the European-North American collaboration, the APHENA project. It was found that in cities with higher proportion of elderly and lower socio-economic status the effect of PM$_{10}$ on mortality is higher. In Europe there was evidence that in cities in which the NO$_2$ levels were higher, PM effects were larger. As NO$_2$ is considered a marker of traffic related pollution, this finding may indicate that particles are more harmful in cities where the source of PM is to a larger extent the traffic. Also in Europe but not in North America it was found that in warmer cities the effects of PM were larger. This latter finding may be indicative of the fact that in warmer European cities (where the prevalence of air conditioning is lower compared to warmer U.S. cities) the population is more exposed to outdoor air pollution, or, alternatively, that the mixture of PM is more toxic [22].

There is evidence that apart from the elderly, other sub-groups are particularly sensitive to the effects of ambient particles. Thus in the HEAPSS (Health Effects of Air Pollution on Susceptible Subpopulations) multi-center European project it was found that that in myocardial infarction (MI) survivors there is a 5.1% increase in the risk of dying after an increase of 10 µg m$^{-3}$ in PM$_{10}$ (compared with 0.6% in the general population) [23]. Thus, it is accepted that the elderly and those with chronic cardiovascular or respiratory conditions form particularly sensitive sub-groups with respect to air pollution effects.

Considering the size distribution of PM, there is some evidence of an association of PM$_{2.5}$ with respiratory and cardiovascular mortality and of the coarse fraction especially with respiratory deaths, from studies done in specific locations. A study attempting to explain the heterogeneity among mortality effects in 60 of the NMMAPS cities, identified higher effect estimates in cities with higher Nickel and Vanadium [24].

**Morbidity outcomes**

From the APHEA study results, the increase of 10 µg m$^{-3}$ in PM$_{10}$ is associated with an increase of about 1% in asthma admissions among children and in respiratory and COPD admissions among the elderly [25]. Also there is an increase in cardiac admissions, more pronounced in the elderly, and especially those for ischaemic heart disease (IHD) [25]. In the NMMAPS study, an increase of 1.2% was found for cardiac admissions and 2% for respiratory admissions after 2 days exposure to increased PM$_{10}$ by 10 µg m$^{-3}$ [19]. Several other studies have reported analogous results for respiratory and cardiovascular hospital admissions and emergency department visits.

Among MI survivors, from the HEAPSS study results, there is a 2.1% increase in the risk of being admitted in hospital after an increase of 10 µg m$^{-3}$ in PM$_{10}$, indicating that persons suffering a previous MI are more sensitive to PM$_{10}$ effects [27]. Results from another multi-center study (AIRGENE) indicate that one possible mechanism for acute effects is through increased inflammation, as IL-6 and fibrinogen were found to increase after exposure of MI survivors to higher ambient PM$_{10}$ concentrations [28]. From panel studies done mainly in children with respiratory symptoms or diagnosed asthma, a decrease of lung function parameters and an increase of medication use and symptoms have been reported [7].

**NOVEL DESIGNS AND FUTURE PATHWAYS OF RESEARCH**

In recent years, there has been significant interest in better assessing the effects of particle components and particle sources. Several studies reported that PM originating from traffic is more toxic compared to that from other sources [29,30]. Particles from other sources, such as long-range transport of Sahara dust and forest fires have been evaluated [31-33]. Some short-term studies have reported results on particle components. Zanobetti et al. reported higher effects of fine PM with metal compounds as well as organic carbon on hospital admissions [34]. Atkinson et al. reported that ultrafine particles are more important for cardiovascular health, whilst secondary pollutants (especially nitrate and sulfate) are more important for respiratory admissions [35]. Ostro et al. found increased effects for traffic PM, sulfates and PM from construction dust in Barcelona [36]. Models based on GIS systems provided more individualized exposure estimates on the spatial scale and recent developments complement this by adding a fine time scale [37]. Emphasis is put on sensitive sub-groups and gene-environment interactions [28].

**THE IMPORTANCE OF RESEARCH IN SOUTHERN EUROPE**

The evidence on geographical heterogeneity of PM toxicity and the identified importance of sources, highlights the significance of local studies on the effects of PM. Especially the finding that PM are, for the same concentration levels, more toxic in warmer cities, is particularly relevant for Southern Europe. This
fact may be due to the specific physical and chemical characteristics of the PM mixture or to the patterns of population exposure (i.e., people may spend more time outdoors in warmer climates). Further research on the role of specific PM characteristics and on the population time-activity patterns is needed.

In order to have an adequate number of good quality studies in all European countries, the main prerequisite is good quality data. Exposure data can be routinely collected for short-term health effect studies and require a good system of continuously operating fixed site monitors. High time and spatial resolution is necessary. Furthermore, the need for complete registration of health outcome data (especially morbidity, since mortality is fully registered) should not be underestimated.

In less developed European economies, the sources of PM are abundant and not well regulated: the vehicle fleets tend to be older, the quality of the fuel is sub-optimal, traffic is more dense and "clean" public transportation more restricted. There is therefore an urgent need to obtain better data, apply local studies, inform the population, as well as the decision makers. Short-term effect studies, which have been pioneers in the past, can offer a relatively cheap, easy and efficient way of assessing health effects of PM and other pollutants.

REFERENCES


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Opšte je prihvaćeno da je zagađenje vazduha, posebno respirabilnim česticama, jedan od najvažnijih problema javnog zdravlja i u Evropi i na svetu. Iako je relativno mali rizik od zdravstvenih efekta po opštu populaciju, ako se utvrdi opšte prisutna izloženost, priznaje se i veći broj događaja. Štaviše, postoji dokaz da utiče veći broj oseća koje su stariji, oni sa hroničnim bolestima, i deca. U okviru velikih projekata, kao što je Aerozagađenje i zdravlje: evropski pristup - APHEA, ispitivan je uticaj geografskih karakteristika na promenu efekata i utvrđen je da je toksicitet čestica povećana u toplijim zemljama, na lokacijama gde su prisutne čestice poreklom od saobraćaja i gde je procenat starijih veliki. Ove karakteristike su posebno značajne na lokacijama Južne Evrope. Na osnovu rezultata niza projekata utvrđeno je da meteorološki, klimatski, uslovi životne sredine i sociokonomski faktori deluju na promenu zdravstvenih efekata specifičnih aerozagađivača. U ovom radu mi ćemo evidentirati kratkotrajne zdravstvene efekte aerozagađenja u vidu čestica i gasova i posebni rezultati koji se odnose na južnu Evropu i potencijalne promene efekata. Biće pokazane praznine u poznavanju i potreba za intenzivnije proučavanje aerozagađenja u zemljama Južne Evrope. Za sprovođenje korisnih istraživanja potrebni su kvalitetni podaci o aerozagađenju i zdravstvenim efektima.

Ključne reči: aerozagađenje, respirabilne čestice u ambijentu, efekti promena, Južna Evropa.