APHEIS Air Pollution and Health: A European Information System

Health Impact Assessment of Air Pollution and Communication Strategy

Third Year Report

2002-2003

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Abbreviations

ACS study	American Cancer Society Study
AirQ	Air Quality Health Impact Assessment WHO software
APHEA	Air Pollution and Health: A European approach
APHEIS	Air Pollution and Health: A European Information System
BS	Black smoke particles
CI	Confidence intervals
E-R functions	Exposure-Response functions
HIA	Health Impact Assessment
ICD	International Classification of Diseases
InVS	French Institute of Public Health Surveillance
LCA	Lung cancer mortality
P5	5^{th} percentile of the distribution of the pollutant
P95	95^{th} percentile of the distribution of the pollutant
PM_{10}	particulate matter less than 10 micrometers of diameter
$PM_{2.5}$	particulate matter less than 2.5 micrometers of diameter
PSAS-9	French national programme on the surveillance of the effects of air pollution on health in nine French cities
RR	Relative risk
SD	Standard deviation
TEOM	Tapered oscillating microbalance method
TSP	Total suspended particulates
WHO-ECEH	World Health Organization European Centre for Environment and Health
YoLL	Years of life lost

Participants in the Apheis programme

Athens: Antonis Analitis, Giota Touloumi, Klea Katsouyanni, Department of Hygiene and Epidemiology, University of Athens, Athens, Greece

Barcelona: Lucía Artazcoz, Antoni Plasència, Agencia Municipal de Salut Pública (Municipal Institute of Public Health), Barcelona, Spain

Bilbao: Koldo Cambra, Eva Alonso, Francisco Cirarda, Teresa Martínez, Departamento de Sanidad, Gobierno Vasco, Vitoria-Gasteiz, Spain

Bucharest: Emilia Maria Niciu, Institutul de Sanatate Publica (Institute of Public Health), Bucharest, Romania

Budapest: Anna Paldy, Eszter Erdei and Janos Bobvos, “Fodor József” Országos Közegészségügyi Központ Országos Környezetegészségugyi Intézet (“Jozsef Fodor” National Center for Public Health, National Institute of Environmental Health), Budapest, Hungary

Cracow: Krystyna Szafraniec, Epidemiology and Preventive Medicine, Jagiellonian University, Cracow, Poland.

Dublin: Pat Goodman and Luke Clancy, Saint James Hospital, Dublin, Ireland

France, PSAS-9 project: Sylvie Cassadou (Toulouse), Pascal Fabre, Hélène Prouvost, Christophe Declerq (Lille), Daniel Eilstein (Strasbourg), Laurent Filleul (Bordeaux), Laurence Pascal (Marseille), Jean François Jusot (Lyon), Myriam D’Elf (Rouen, Le Havre), Agnès Lefranc, Benoit Chardon (Paris), and Alain Le Tertre, Institut de Veille Sanitaire, Saint-Maurice

Ljubljana/Celje: Tina Gale, Peter Otorepec, Mateij Gregoric, Inštitut za Varovanje Zdravja RS, (Institute of Public Health), Ljubljana, Republic of Slovenia

London: Richard Atkinson and Ross Anderson, Saint George’s Hospital Medical School, London, UK

Madrid: Mercedes Martínez (Dirección General de Salud Pública), Belén Zorrilla, Laura Lopez, Ana Gandarillas, Elena Boldo (Instituto de Salud Pública) Consejería de Sanidad, Laura Crespo (Dirección General de Calidad y Evaluación Ambiental) Consejería de Medio Ambiente, Comunidad de Madrid (Department of Public Health, Regional Ministry of Health, Madrid Regional Government), Madrid, Spain.

Rome: Ursula Kirchmayer and Paola Michelozzi, ASL RM/E Azienda Sanitaria Locale Roma E (Local Health Authority Roma E), Rome, Italy

Seville: Inmaculada Aguilera, Antonio Daponte, Escuela Andaluza de Salud Pública (Andalusian School of Public Health), Granada, Spain

Stockholm/Gothenburg: Bertil Forsberg, Bo Segerstedt, Lars Modig, Umeå Universitet, Institutionen főr folkhalsa och klinisk medicin (Umeå University, Department of Public Health and Clinical Medicine), Umeå, Sweden

Tel-Aviv: Sarah Hellmann, Ayana Goren, Department of Epidemiology and Preventive Medicine, Tel-Aviv University, Tel-Aviv, Israël

Valencia: Ferrán Ballester, Carmen Iñíguez and José Luis Bosch (City Council), Escuela Valenciana de Estudios para la Salud (Valencian School of Studies for Health), Valencia, Spain

Steering Committee

Ross Anderson, Saint George's Hospital Medical School, London, UK

Emile De Saeger, Nikolaos Stilianakis, Joint Research Centre, Institute for Environment and Sustainability, Joint Research Centre Ispra, Italy

Klea Katsouyanni, Department of Hygiene and Epidemiology, University of Athens, Athens, Greece

Michal Krzyzanowski, WHO European Centre for Environment and Health, Bonn Office, Germany

Hans-Guido Mücke, Umweltbundesamt - Federal Environmental Agency, WHO Collaborating Centre, Berlin, Germany

Joel Schwartz, Harvard School of Public Health, Boston, USA

Coordinators

Sylvia Medina, Institut de Veille Sanitaire (French Institute of Public Health), Saint-Maurice, France

Antoni Plasència, Agencia Municipal de Salut Pública (Municipal Agency of Public Health), Barcelona, Spain

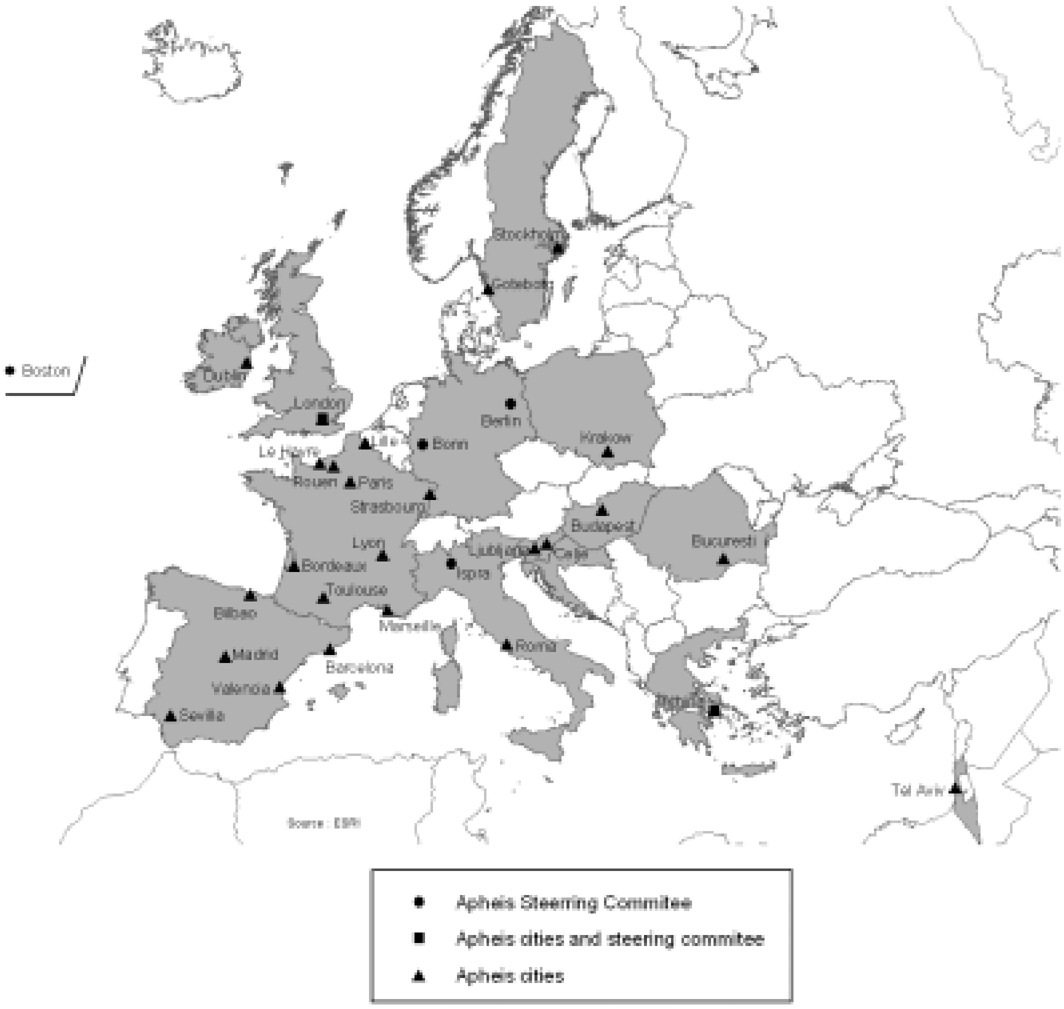
Contact

Sylvia Medina, programme coordinator
Dept. of Environmental Health, French Institute for Public Health Surveillance, Institut de Veille Sanitaire (InVS), 12 rue du Val d'Osne, 94410 Saint-Maurice Cedex, France. email: s.medina@invs.sante.fr. fax: +33-1-41-79-67-68.

Apheis Web site

www.apheis.net

How is Apheis organised



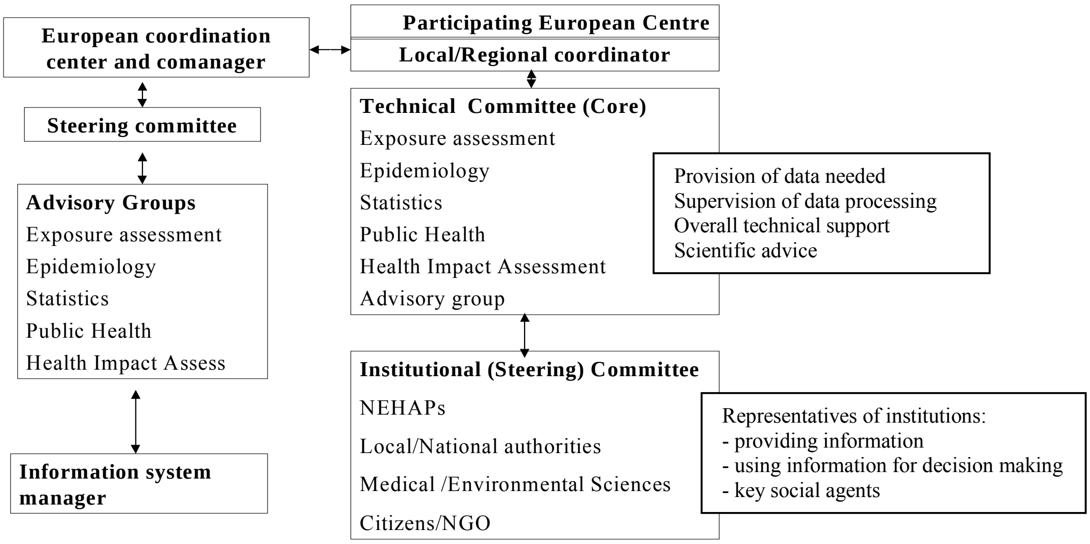
The Apheis programme comprises 16 centres totalling 26 participating cities in 12 European countries (Figure A).

Figure A. APHEIS centres by country

Country	Centres	Cities
France	France (PSAS-9 Programme)	Bordeaux Le Havre Lille Lyon Marseille Paris Rouen Strasbourg Toulouse
Greece	Athens	Athens
Hungary	Budapest	Budapest
Ireland	Dublin	Dublin
Israel	Tel Aviv	Tel Aviv
Italy	Rome	Rome
Poland	Cracow	Cracow
Romania	Bucharest	Bucharest
Slovenia	Slovenia	Celje Ljubljana
Spain	Barcelona Bilbao Madrid Seville Valencia	Barcelona Bilbao Madrid Seville Valencia
Sweden	Sweden	Gothenburg Stockholm
United Kingdom	London	London

Each Apheis centre is part of a local, regional or national institution active in the field of environmental health. The organisational models (Figure B) that support the development of Apheis are ample and diverse in terms of technical and scientific areas of expertise (for example the Advisory Groups and Technical committees) and are functioning well. On the other hand, it is desirable to involve decision makers more deeply in the organisational models needed to support Apheis activities through the Institutional (Steering Committees).

Figure B. APHEIS general organisational model and functions



For more details on Apheis organisation:

Medina S., Plasència A., Artazcoz L., Quénel P., Katsouyanni K., Mücke HG., De Saeger E., Krzyzanowsky M., Schwartz J. and the contributing members of the APHEIS group. APHEIS Monitoring the Effects of Air Pollution on Public Health in Europe. Scientific report, 1999-2000. Institut de Veille Sanitaire, Saint-Maurice, March 2001; 136 pages (**www.apheis.net)**

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Introduction

The Apheis programme seeks to meet the information needs of individuals and institutions in Europe concerned with air pollution, which continues to have a significant impact on public health. Communicating about the health effects of air pollution thus lies at the core of the Apheis programme, and constitutes a key objective that we are addressing for the first time in this, the programme's third year.

As a reminder, Apheis was created in 1999 to provide European policy and decision makers, environment and health professionals, the general public and the medias with an up-to-date, easy-to-use information resource on air pollution and public health to help them make better-informed decisions about the political, professional and personal issues they face in this area.

To develop this information resource, Apheis has created a public-health surveillance system that generates information for HIAs (health-impact assessments) of air pollution in Europe at the city, regional, national and European levels, on an ongoing basis.

Apheis-1 and Apheis-2

During the first phase known as Apheis-1, we achieved two key objectives:

- We defined the best indicators for epidemiological surveillance and HIAs of the effects of air pollution on public health in Europe. For this purpose, Apheis created five advisory groups in the fields of public health, health-impact assessment, epidemiology, exposure assessment and statistics. These groups drafted guidelines that define the best indicators for epidemiological surveillance of the effects of air pollution on public health in Europe, and provide a standardized protocol for data collection and analysis.
- We identified those entities best able to implement the surveillance system in the 26 cities in 12 European countries participating in the programme. We understood how the different entities could work together on the local, national and European levels. And we assessed each entity's ability to implement, during the programme's second phase, an HIA of particulate pollution using the guidelines drafted by the advisory groups (Medina et al, 2001).

During the second phase, Apheis-2, among other tasks Apheis used its epidemiological surveillance system to conduct an HIA of PM_{10} and black smoke (BS) applying the above guidelines to gather and analyse pertinent data. This first HIA found between 544 and 1 096 "premature" deaths that could be prevented annually if, all other things being equal, short-term exposure to outdoor concentrations of PM_{10} were reduced by 5 $\mu g/m^3$ in the Apheis cities. On the other hand, the expected benefits of reducing long-term mortality were still greater. The HIA estimated that, all other things being equal, between 3 368 and 7 744 "premature" deaths could be prevented annually if long-term exposure to outdoor concentrations of PM_{10} had been reduced by 5 $\mu g/m^3$ in each city. Apheis published the findings of this work in its second-year report, "Health Impact Assessment of Air Pollution in 26 European Cities" (Medina et al, 2002).

Apheis-3

In the third phase, Apheis-3 planned to develop a communications strategy and update the HIA using its epidemiological surveillance system.

In specific, Apheis-3 phase had the following objectives:

- **Communications strategy**: Develop a strategy to communicate the effects of air pollution on health to key audiences. As a first step, understand how best to meet the information needs of decision-makers and advisors together who constitute one of the many key European audiences concerned with the impact of air pollution on public health; and test the Apheis report's usefulness for meeting their needs.
- **Health impact assessment**: Through our epidemiological surveillance, update the estimates of the effects of air pollution on health and establish new all-ages respiratory exposure-response functions (E-R functions) suitable for HIA; introduce methodological innovations to improve the estimated impacts of short-term changes in exposure to air pollution and calculate reduction of life expectancy, beside the absolute number of cases, to estimate the health impacts of long-term exposure to air pollution.
- **Collaboration**: Investigate the possibility of making a geographical representation of the Apheis findings by collaborating with Euroheis (also funded by the programme Action on Pollution Related Diseases).

How this report is organised

In this report, the first section presents a summary report on the Apheis communications strategy. The second section describes how we conducted the HIAs and includes epidemiological findings. We then present and compare the characteristics and the HIAs of the participating cities. The following section describes how to interpret the findings, followed by the main conclusions.
A separate report comprises the appendices on the communications strategy, exposure assessment, epidemiological and statistical analysis, health-outcomes assessment, HIA tools, summary of Apheis-2 findings, the EC directives on PM_{10}, the EC Directives-WHO/EC assessment on $PM_{2.5,}$ and the Euroheis collaboration.

We have produced 26 city-specific reports, which appear on the Apheis Web site.

Developing an Apheis Communications Strategy

Summary Report

Prepared by Michael Saklad, Saklad Consultants

April 22, 2004

Developing an Apheis Communications Strategy

Executive Summary

> *"The DETR (UK Department of the Environment, Transport and the Regions) has had little success ensuring that anyone takes any notice of the information provided." – Dr. Erik Millstone, Science and Technology Policy Unit, Sussex University*

The Apheis programme seeks to meet the information needs of a wide range of individuals and organizations concerned with the impact of air pollution on health in Europe; and most importantly the needs of those individuals who influence and set policy in this area on the European, national, regional and local levels.

Like other providers of scientific information, however, Apheis had reason to believe that its many audiences, and this one in particular, were making little use of the scientific reports it produces.

To ensure it meets the needs of policy advisors and makers, Apheis decided to develop a communications strategy based on learning this key audience's needs directly from its members.

For this purpose, Apheis interviewed 32 individuals who influence or set policy on air pollution and health in the UK and Spain and who are active in the fields of public health and the environment.

Through this research Apheis sought to describe this audience's information needs as accurately as possible; and then produce recommendations for developing communications tools that would help the audience's members best understand, absorb, process and act on the information Apheis provides.

Our research showed in particular that:

- Policy advisors and makers are generally unlikely to use the scientific reports we develop as is, contrary to scientists

- Each of our two audiences of scientific and policy users has different problems to solve, different ways of processing information, different levels of scientific knowledge and different cultures, meaning each audience has different information needs
- A long, complex chain comprising many players leads from the scientists to whom we distribute our reports directly, and who use them, to the policy makers who ultimately have the greatest effect on public health, but who only receive our reports indirectly and use them rarely, if at all.

Based on this evidence, we concluded that Apheis needs to act proactively to:

- Apply this knowledge to the way it shapes and delivers its information and messages
- Develop a range of communications tools that goes beyond our comprehensive scientific reports to include summary reports, brochures, presentations and Q&As whose focus, content and form are tailored to the separate information needs of scientific and policy users
- Ensure that the information needed by policy advisors and makers actually reaches them.

Taking these steps will greatly enhance the way Apheis communicates with the key audiences that set policy on air pollution in Europe, and will thus help Apheis contribute better to improving public health.

Developing an Apheis Communications Strategy

Summary Report

What is the mission of Apheis, and how has Apheis fulfilled it so far?

The Apheis programme was created in 1999 for the stated purpose of "providing European policy makers, environment and health professionals, the general public and the media with up-to-date, easy-to-use information on air pollution and public health to help them make better-informed decisions about the political, professional and personal issues they face in this area."

To fulfill this mission, during its first phases of work, Apheis has conducted health impact assessments on particulate pollution in 26 European cities using a standardized methodology. It then published its findings in the form of scientific reports.

Why develop a communications strategy?

As the next, key step in fulfilling its mission, during its third phase the Apheis programme wanted to go beyond just ensuring that its findings were scientifically valid and up-to-date.

Through this next step, Apheis also wanted to make sure its findings were relevant to the needs of its chosen groups of users, or audiences; that these audiences could easily use its findings; and that, to the extent possible, these audiences would actually use the work of the many individuals who give so much of their time and energy to the Apheis programme.

Indeed, it wasn't clear to us that the content and form of the information Apheis was producing were relevant to our users' needs and easy for them to use, or that our audiences were actually using our work when making decisions or acting on the information we provided.

At Apheis we had been producing reports from our own perspective with hypothetical audiences in mind. This approach caused us to fear our reports were sitting unread on potential users' shelves. And what scientists at other institutions told us about low usage of their reports only heightened our worries.

Given this situation, we resolved that Apheis would first study and seek to understand the seeming communications gap between our knowledge and our audiences' use of it, and then act on our understanding to bridge this gap. Through these two steps we hoped to close the apparent divide separating the world of our research and output from the ability of our users to understand, absorb, process and act on it.

We thus set about designing the Apheis Communications Strategy Project to close the gap between those who produce scientific information and those who use it.

What are the objectives of the communications-strategy project?

At the beginning of the project we first wanted to identify our users. By the broadest possible definition, we determined that those European audiences concerned with the impact of air pollution on public health -- and thus potential users of information produced by Apheis -- included such varied groups as:

- Government policy makers and influencers
- The media that inform and influence government policy makers and influencers, and other audiences
- Environment and health professionals who perform a similar role
- Industry and transport sectors, which include manufacturing industries and automotive manufacturers that pollute the atmosphere directly or indirectly
- Health-care providers who serve the needs of the public
- Vulnerable members of the population who seek to meet their special needs
- The general public

We also determined how we hoped those audiences would use the information we produced. This included doings such things as:

- Improve the measurement of exposure to air pollution
- Incorporate our data and findings in scientific reports
- Pass our reports on to influencers and decision makers
- Influence and make policy decisions on air pollution and public health
- Disseminate information to the general public
- Inform and advise patients on preventive health measure
- Make industry decisions
- Make decisions about personal behavior

Then, to ensure we achieved our goal of bridging the gap between Apheis and the audiences we had identified and what we hoped they would do with the information we produce, we set ourselves four key objectives:

- Identify the information needs of users of our work, our findings and our reports
- Understand how well we were meeting those needs with the reports we had produced
- Understand what we needed to do to meet users' needs better
- Develop a communications strategy that would identify and describe the communications tools, content and characteristics that would best meet the information needs of specific user groups effectively and efficiently

What methodology did we use?

Target audiences and research sites

Given various budgetary and time constraints, to meet the project's stated objectives Apheis chose in a first phase to narrow the project's scope and investigate the information needs and behavior of a single, key target audience from among the large number of target audiences that require information on the impact of air pollution on public health.

From all the potential target audiences that deserved investigation, we chose government policy makers and influencers, since through their actions this group probably has the greatest impact of all our target audiences on improving public health.

To gain the best possible understanding of the chosen target audience, we decided to concentrate our investigations on members of this audience in a single country, and treat this research as a core case study.

By concentrating on one country, the UK, and specifically on one city within that country, London, that together have long experience both in the area of air pollution and public health and in its communications aspects, we hoped to form a rich, clear and concise picture of the thought and communications processes and information needs of our chosen target audience, and of the best practices for meeting those needs.

At the same time, we recognized the limitations of conducting research in a single country. Indeed, we felt that cultural, historical, regional, environmental or other reasons might prevent our findings concerning the audience in the UK from being directly applicable to the same or to other key target audiences in other Apheis countries.

To make the findings of our core case study more useful to the Apheis centers, we thus decided to enrich the findings of the core case study with the findings of a complementary case study conducted in two southern European cities, Barcelona and Madrid, where levels of air pollution were high and where people were just becoming aware of its damaging impact on public health. We also decided to model this complementary case study on the core case study, and use the second study to validate and broaden the findings of the first.

To further enrich the findings of these case studies and make them even more useful to all 26 Apheis centers, we asked those centers to provide minicase studies on their local communications needs and experiences; and to comment on the applicability of the two main case studies to developing local communications content and tools.

Subgroups we investigated within the target audience

While members of the chosen target audience can be grouped together under the single rubric of government policy makers and influencers, we determined that this audience in fact comprises many key subgroups that deserved investigating. Among others, these subgroups included combinations of the following:

- Individuals who make decisions directly regarding public policy
- Individuals who influence the making of such decisions
- Individuals active on the European, national, regional and local levels
- Individuals who recognize the benefits of reducing air pollution to improve public health and advocate such moves
- Individuals who reject, deny or question the benefits of reducing air pollution to improve public health, and who actively or passively oppose such moves
- Individuals who require technical information
- Individuals who require nontechnical information

To obtain the best possible picture of our chosen target audience, we conducted 21 interviews for the core case study and 11 interviews for the complementary case study, all with individuals who combined the above characteristics in the following subgroups.

Direct advisors to government policy makers

While interviewing government policy makers, such as a European or country minister, a region's administrator or a city's mayor would have been highly informative, we couldn't reasonably expect to reach such busy people. Hence, we decided instead to gather information from the individuals who directly influence this topmost group of policy makers.

We thus chose to investigate individuals closest to government policy makers, in specific their direct advisors and members of their close political entourage. Members of this subgroup advise the policy maker directly, or the policy maker consults them directly for opinions and recommendations.

To get a representative view of this subgroup, we interviewed subjects in the UK and Spain who formed a cross section of individuals active on the European, national, regional and local levels.

Policy influencers

The policy influencers we investigated included representatives from the two key subgroups of individuals active in the field of public health and in the field of the environment.

Contrary to the previous subgroup, members of these subgroups are not direct political advisors to government policy makers or members of such individuals' close political entourage.

However, they are members of European, national, regional or municipal government bodies who consult with, advise or otherwise influence government policy makers or members of their political entourage.

To get a representative view of the subgroups of policy influencers from both the public-health and environment sectors, we again interviewed subjects in the UK and Spain who formed a cross section of individuals active on the European, national, regional and local levels. And we achieved a good balance of individuals from both sectors.

Topics we investigated

To gather information for our research, Apheis conducted one-on-one interviews, mostly in person, with key members of the above subgroups in the UK and in Spain.

The research focused on investigating the following main topics:

- What information do members of the target audience and those they influence require about the impact of air pollution on public health (this included areas of information wanted and level of scientific detail required)
- What is the decision-making process in which the target audience participates, and how does it work; who else participates in the process
- Who uses information on the impact of air pollution on public health (this includes both the target audience itself and pass-on users who can not be interviewed but with whom the target audience communicates, who require and request such information from the target audience

as part of the decision-making process, and who are thus users of the information in their own right)
• For what purposes do these different individuals use that information, and how do they use it
• Which types of communications tools, content and form meet the information needs of these individuals, which don't, and why
• How well do the Apheis 2 draft report as a whole, and the compilation of findings and city reports individually, meet their information needs; is the content relevant, clear, understandable and usable; what's lacking in the content and in how that content is presented, what needs to be changed, and how

What did we learn?

What attitudes did subjects hold about reducing air pollution?

On the whole, the 32 subjects interviewed showed a general willingness to advocate reducing air pollution. At the same time, they pointed out a need to compare air pollution with other public-health hazards, such as indoor sources.

Subjects in the UK indicated they expected the already marginal benefits of reductions in London air pollution to decrease even further while costs increased. Spanish subjects gave higher priority to reducing air pollution than did those in the UK. And there was a general call for Europe-wide policies, since some subjects felt local actions alone won't be effective, citing ozone reduction as an example.

What information can raise awareness of the impact of air pollution on health?

Subjects suggested different types of information they felt could help raise awareness among policy makers and influencers of the impact of air pollution on health.

These included providing peer-reviewed papers; cost-benefit analyses; information on health benefits and health-impact assessments; maps of air pollution and health-impact assessments that show inequalities in exposure and in health effects; and comparative risk assessments for air pollution and other environmental factors.

Other suggestions included emphasizing long-term effects and years of life lost; and providing the media with information on the health effects of air pollution.

Spanish subjects also recommended providing comparative figures across cities; comparisons with other health hazards; and use of strong graphical presentation of evidence.

How did subjects rate the Apheis 2 draft report?

All subjects interviewed received the first draft of the Apheis 2 report, which included a compilation of findings section and a sample city report. Subjects were then asked to rate the documents on scientific soundness, trustworthiness, relevance of content to their needs, and organization and presentation of information.

All subjects interviewed in Spain rated the Apheis documents favorably to very favorably overall, and rated them slightly better than did the subjects interviewed in London.

Subjects in London active in the environment sector found the Apheis 2 draft report to be more useful than did those active in the public-health sector, contrary to subjects in Spain, where subjects in the public-health sector rated the Apheis 2 draft report as more useful than did those in the environment sector.
Subjects generally praised the compilation of findings and the city reports for providing a detailed, comparative picture of air pollution and health in different European cities.

At the same time, a number of general and specific comments indicated there was room for improvement. One subject felt that, "The Apheis 2 reports fell between two stools," reflecting a need to develop different communications tools for different Apheis audiences. Other subjects suggested including a glossary, and some called for more balanced writing when reporting deaths related to exposure to air pollution.

In addition, some Spanish subjects felt the reports should use simpler language, and more boxes, graphs, maps and colors.

What recommendations did subjects make for the compilation of findings?

Specific recommendations made by subjects concerning the compilation of findings section included the need to:

- Provide an executive summary of the findings
- Stress that Apheis uses a standardized methodology for quality control, data collection and analysis
- Indicate by how much deaths are brought forward (years of life lost or reduction in life expectancy)

- Explain uncertainties better (e.g., GAM modeling problems)
- Deal with the transferability of exposure-response functions (e.g., use of shrunken estimates)

What recommendations did subjects make for the city reports?

Specific recommendations made by subjects concerning the city reports included the need to:

- Provide an executive summary of local findings
- Indicate clearly if the report is for a nonscientific audience (in which case only provide the central estimate) or if it is for a scientific audience (provide more detailed methodological information and interpretation)
- Comment on implications for local transportation policy
- Provide comparative information with other cities
- Use clearer, simpler writing, and more bullet points

Who are the audiences for our work?

The key objectives of the Apheis Communications Strategy Project call for ultimately providing the different users of our work with information chosen and presented in such a way that it is relevant to the needs of each group of users, or audience, and that each audience would find our information easy to use, thus ensuring it has an impact on policy making. Successfully achieving this objective thus meant understanding the information needs of each of our audiences.

As a reminder, in its first phase the project sought to meet the needs of both policy influencers and of direct advisors to government policy makers. Different individuals in these chosen groups, though, have different levels of knowledge about air pollution and its impact on health, and thus have different information needs; and they process information differently depending on their role in the decision-making process.

Given this diversity of needs and behavior, to meet its objectives effectively Apheis clearly needed to develop different communications tools (reports, brochures, slide presentations and so forth) and different types of content, and tailor each tool and its content to the needs of a specific group of individuals, all of whom share common information needs.

We called these groups “target communications audiences,” and as a first step in our analysis we sought to define the characteristics of these groups and their information needs.

To determine who the audiences of policy influencers and of direct advisors to government policy makers are for the information Apheis produces, we first sought to understand how policy on air pollution is made and by whom. For this purpose we drew on what we learned in the interviews conducted in London, Madrid and Barcelona, and on the analysis Saklad Consultants has conducted of complex decision-making processes in large organizations.

The diagram in Figure 1 below, which emerged from this work, portrays a chain of decision influencing and making -- and the information needed for this process -- that comprises multiple paths leading from Apheis as a source of information through scientists and scientific committees to policy advisors and, ultimately, to the policy makers themselves, seen at the bottom of the diagram.

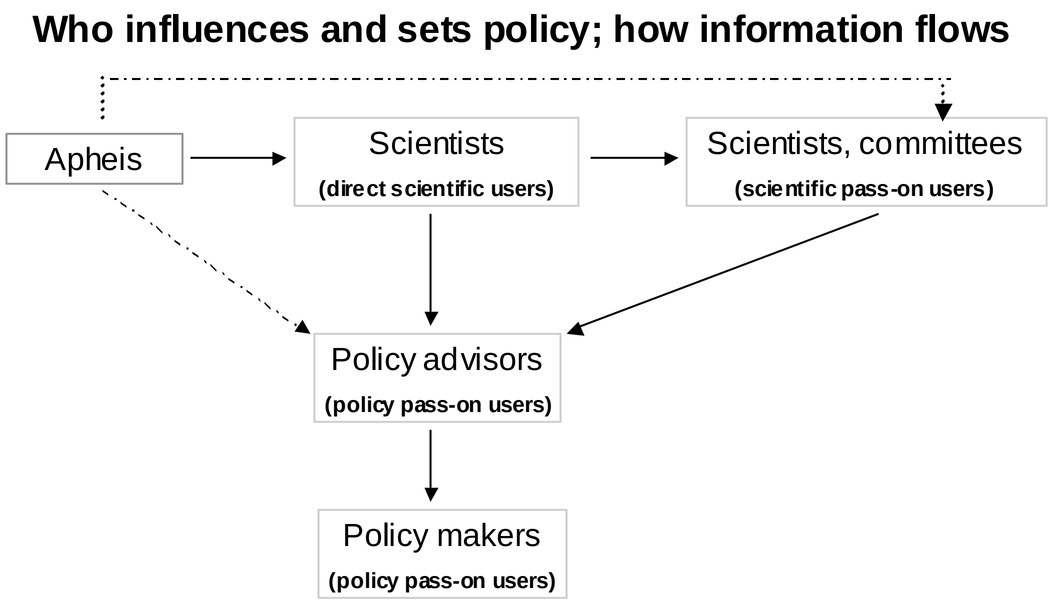
The diagram also shows the three main groups of people who receive and process the information Apheis produces. These are the direct scientific users, the scientific pass-on users and, below, the policy pass-on users.

The solid lines in the diagram indicate the main paths of information flow, while the dotted lines show the secondary paths of information flow.

It's worth noting that our research revealed that this general decision-making process, and the information flows that make it work, seem to apply across all local, regional, national and European levels of policy making.

As the diagram shows, the policy-making process includes what we call direct users of Apheis information, and indirect users, also known as pass-on users, as indicated in parentheses in the different boxes.

Figure 1: Who influences and sets policy and how information flows



Direct users of the information Apheis produces and disseminates include the scientists who appear just to the right of the Apheis box and who receive information directly from Apheis.

These scientists in turn pass that information on to other scientists and to committees, seen in the box further to the right, all of whom thus become pass-on users, because they receive the information Apheis produces indirectly from Apheis.

Then, the individual scientists and committees pass Apheis information on to the policy advisors below them, who form another group of pass-on users. And those policy advisors in turn pass the information on to policy makers, who review it and set policy.

To summarize, Apheis sends the information it produces to the people with whom it is in closest contact: primarily to scientists, as indicated by the solid line; and, to a lesser extent, to scientific committees and, infrequently, to policy makers, all as indicated by the dotted lines.

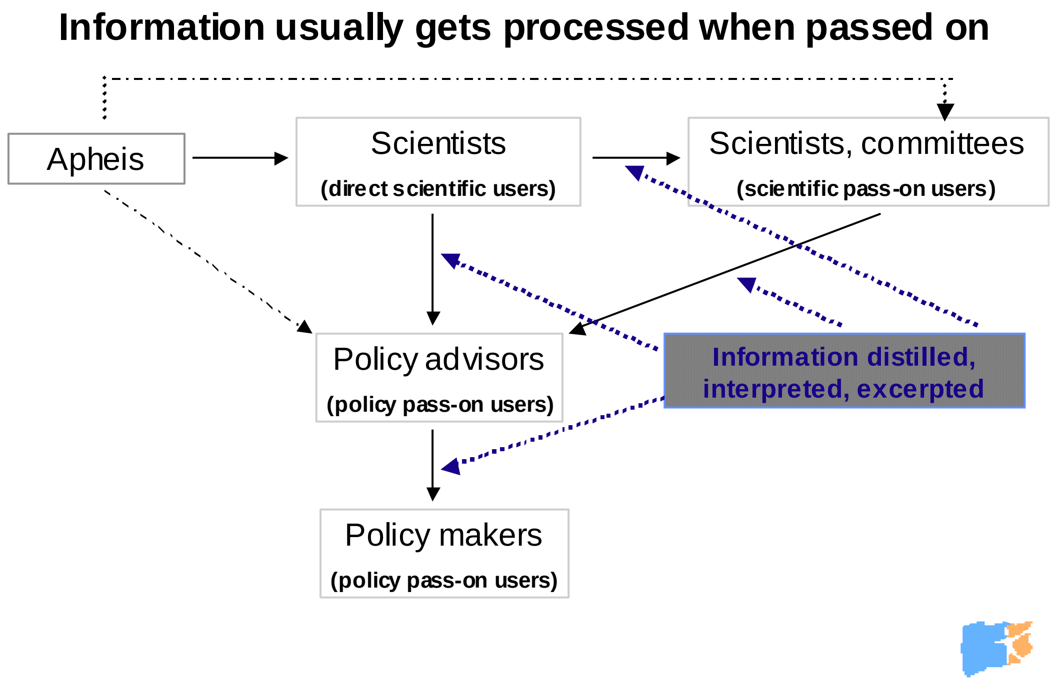
Note that, although this diagram provides a collapsed view of a complex process that comprises many different players and steps, it accurately reflects how policy on air pollution is set, who the different players are in that process, and how the information they need flows through the decision-making chain.

We have used this model to develop the Apheis communications strategy and to determine specifically with which audiences we need to communicate, what information each audience needs, and in what form they need it.

Figure 2 below adds a new and important layer of information to Figure 1, and shows that information is processed at virtually every step in the policy-making process.

By processed, we mean that individuals distill, interpret and extract the information they receive; frame it to meet various policy needs -- political, social and economic, among others; and usually incorporate the resulting information in other, often shorter documents for use by themselves and by others.

Figure 2: information usually gets processed when passed on



The arrows that point from the box labeled "Information distilled, interpreted, excerpted" indicate where this processing occurs. So for instance, scientists and committees process information before handing it on to policy advisors, and policy advisors do the same before handing information on to policy makers.

And at the end of the chain, complex scientific information often gets boiled down to just a few pages and messages that reach the desks of the policy makers themselves.

What this means is that a series of people, with whom Apheis has little or no contact, extract what they want from the reports Apheis produces, and interpret it in ways over which Apheis has essentially no control.

Apheis thus needs to devise ways to control this process of distillation and interpretation better if it is to ensure that its work reaches the policy makers at the end of the chain both intact and in compelling form, rather than truncated inappropriately, distorted or weakened. Understanding this need to address each step in the policy-making process will inform the design and content of the communications tools Apheis develops.

Now let's examine more closely who the various players in this chain are, and what they do with the information they receive.

Who are the direct scientific users?

As we saw in the preceding diagrams, direct scientific users are the first link in the chain of scientists, committees and advisors that ultimately leads to government officials who set policy. Direct scientific users serve as the point of contact at which our information enters the decision-making chain, since they receive the information Apheis produces directly from us.

Our research told us that few of these direct scientific users advise policy makers directly; instead they advise policy advisors directly, and also indirectly through other scientists, committees, groups, agencies and departments, some of which are scientific and some political in nature.

As for what direct scientific users do with the information they receive from Apheis, some read our Apheis reports and make recommendations to others in the chain in writing, in meetings and in conferences. Some direct scientific users pass Apheis reports on to other scientists and to policy advisors as is, while some distill, interpret or excerpt it, and incorporate it in other documents. And some just read Apheis reports to keep informed.

Who are the scientific pass-on users?

Scientific pass-on users include fellow scientists who need information for the same purposes as direct scientific users. Scientific pass-on users also include scientific committees that gather information on a variety of subjects, review data and make recommendations, and pass reports on to policy advisors, again sometimes as is, and sometimes distilled, interpreted and excerpted or incorporated in other documents.

Who are the policy pass-on users?

Policy pass-on users include policy advisors, who prepare briefings for policy makers who in turn use them to make decisions on often complex public-health and environmental issues. Policy advisors exert greater influence on policy makers the closer they are to them.

Policy pass-on users also include policy makers themselves, who are generally not scientists. But policy pass-on users sometimes include scientists who advise and influence policy makers directly, or are policy makers themselves.

Policy pass-on users generally deal with political, economic and social issues. They tend to be less technically knowledgeable than scientists. And they prefer synthesized information presented and framed in terms of the issues they face.

For these reasons, policy pass-on users tend to read brochures, slide presentations and Q&As/FAQs (questions and answers/frequently asked questions), and told us that scientific reports are generally not relevant to their information or policy-making or -influencing needs.

What should our communications strategy be?

What do these findings mean for Apheis communications?

We have seen that a chain leads from the scientific data and analysis produced by Apheis to the setting of policy on air pollution. Individuals, committees and groups form successive links in that chain. And the closer individuals are to policy makers, the less technically knowledgeable they tend to be about air pollution and its impact on health.

We have also seen that many individuals in the policy-making chain distill, interpret and frame scientific content to make it understandable to the next user in the chain.

During our research, subjects told us that time is a critical factor when it comes to their absorbing written information (even two pages can be too many for some), and when they process and prepare information to pass on to others. They also said that having Apheis do the job of distilling, interpreting and framing information for them makes all the difference.

To understand how doing their job for them can benefit Apheis, let's take the example of a scientist or policy advisor involved in the policy-making chain. The next person in the chain after them closer to policy making has asked the scientist or policy advisor to boil down the Apheis report, frame the information it contains in terms he or she can understand, and shape it as a slide presentation or a briefing paper.

That scientist or policy advisor may very well not understand all the technicalities of the Apheis report, or the meaning or implications of the information it contains for the issues facing the next person in the chain. And chances are that scientist or policy advisor is also pressed for time in their job.

What this means is that, if Apheis has already developed such a document for that scientist or policy advisor to hand on to the next person in the chain, that scientist or policy advisor is more likely to pass it on as is and not modify, distort or misinterpret the information it contains when shaping it for the next user's needs.

From having interviewed many people in large organizations, this consultant knows that key individuals active in decision-making processes face this problem of preparing information for pass-on users almost on a daily basis; and that having the information provider prepare communications tools for the next person in line takes a heavy burden off their shoulders, makes them more likely to use the information provided -- and use it as is -- and gains their appreciation and goodwill.

Even more importantly, preparing tools for pass-on users means that the information Apheis produces will keep moving through the decision-making process rather that sitting unread and unused on someone's shelf, in a stack of folders on their desk or in their drawer.

What options does Apheis have for its communications?

Based on the above analysis, the Apheis programme has two choices concerning its communications, each with different consequences.

Apheis can continue to produce scientific reports alone, as it does today, and in their current form. Doing so will leave it up to each individual in the chain to distill, interpret, frame and communicate the information Apheis produces as they see fit and in the time available to them.

This means that Apheis will only reach the first, scientific link in the policy-making chain. Apheis will have no control over how its information is then processed or manipulated. People pressed for time or who don't understand the information Apheis produces will most likely neither process nor use it, or will misunderstand or distort it. And as a result, as we said Apheis reports will mostly likely sit on shelves unread and unused.

On the other hand, if the Apheis programme takes a proactive stance, the outcome will be radically different, and will lead to far greater use of the information Apheis produces.

In this scenario, Apheis would anticipate the needs of all individuals in the policy-making chain, from the initial scientists knowledgeable about the field of air pollution and health to policy advisors and makers who often have little familiarity with or understanding of our work, its concepts or its vocabulary. This means Apheis would prepare the information people need at each step in the chain in the form of communications tools tailored to their respective needs.

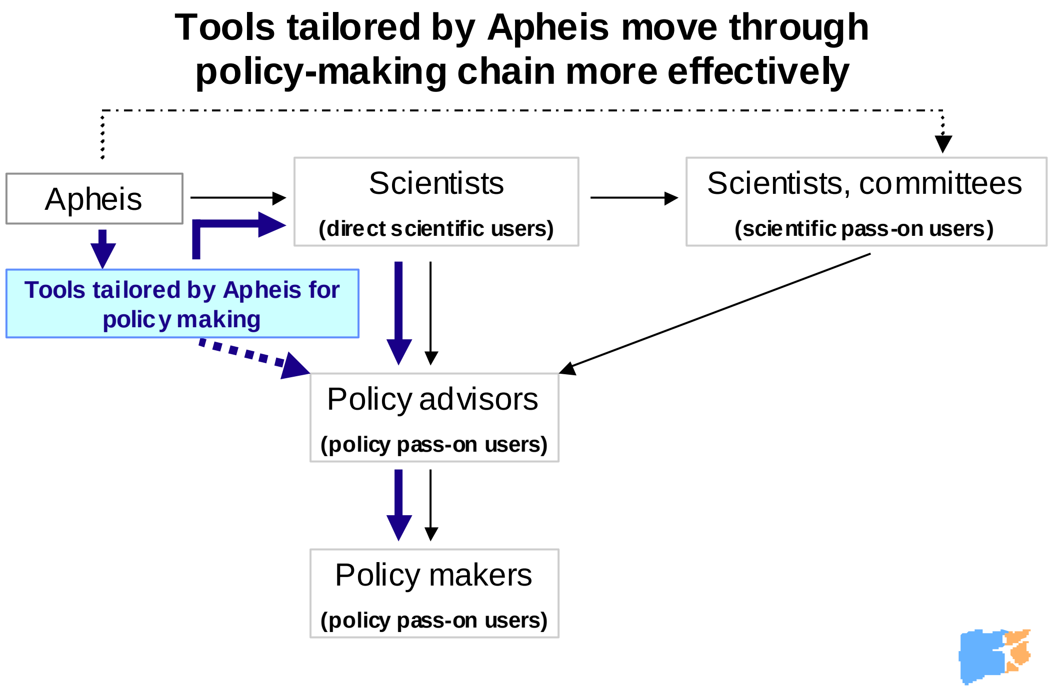
In other words, Apheis would speak to everyone in the chain at the same time but using different words and voices in different tools.

In addition, because Apheis lacks direct access to key policy advisors and makers, to ensure these target audiences receive the information it produces, Apheis needs to deliver the tools tailored to their needs to the individuals in the process who have access to these key but hidden pass-on users and who will pass our information on to these hard-to-reach policy advisors and makers.

If Apheis both prepares the right communications tools *and* gets them into the hands of those individuals who have access to key policy advisors and makers, the information Apheis produces will be far more likely to flow unimpeded through all the links in the policy-making chain and thus reach all the players with the greatest integrity, relevance and impact, thereby truly fulfilling Apheis' mission.

Figure 3 illustrates such a scenario, in which Apheis produces both scientific reports for scientists and communications tools tailored specifically to the needs of policy advisors and makers, and provides the latter to both scientists and policy advisors directly for their own use and for passing on to others.

Figure 3: Tools tailored by Apheis move through policy-making chain more effectively



Since it seems reasonable to assume that the Apheis programme prefers this type of proactive approach, we will now look at what that approach actually requires in order to produce communications tools and content tailored to the needs of everyone involved in influencing and making policy.

For this purpose, we'll first report what information content each group of users wants based on our research. Then we'll look at the communications tools they prefer that deliver that content, whether those tools are complete reports, peer-reviewed papers, brochures, slide presentations and so forth, and what they do with them when influencing and making policy decisions.

What information do direct and pass-on scientific users need?

Our research revealed that subjects active in the public-health sector in general asked for comparative figures across Europe for air pollution and health; exposure-response functions and HIA scenarios on mortality and morbidity; and health data for background prevalence or incidence rates.

In addition, subjects in Spain wanted to understand the public's perception of air pollution and its impact on health; and wanted to understand the threat of air pollution more in terms of public health than in terms of exposure-response functions.

Subjects active in the environment sector generally wanted Apheis to monitor trends in air pollution and health effects; they wanted meta-analytic findings and comparative figures; they wanted to know how the public perceives air pollution and its impact on health as determined by willingness-to-pay studies; and they wanted to understand policy options and their effectiveness.

Subjects in Spain also asked for information on industrial emissions, sources, technology used and related levels of air pollution; information on the seriousness of air pollution; and information on air-pollution legislation and on years of life lost.

What information do policy pass-on users need?

Policy pass-on users generally asked for information on air-pollution levels and sources; health effects; HIA scenarios; health costs related to air pollution and the costs of reducing air-pollution levels; and information on ad-hoc subjects.

What did we learn from the minicase studies?

In minicase studies, some of the Apheis centers reported on their local communications experiences following publication of the Apheis 2 report. In these studies they reported an increased awareness of air pollution and its impact on health in several cities like Bucharest, Budapest, Ljubljana and Stockholm, and in some cities in France and Spain.

They also observed some resistance to the dissemination of Apheis 2 findings coinciding with political elections.

Requests for information from local Apheis centers included a focus on susceptible populations (defined by their SES, age, history of disease and exposure to hotspots); the inclusion of more degrees of severity (other than mortality); a focus on areas “at risk”; the inclusion of specific HIAs of traffic-related air pollution; the development of HIA tools and different scenarios; and the inclusion of comparisons with other cities in the city report.

Which communications tools do Apheis audiences want?

When asked to rank the communications tools they deemed most useful for their needs, subjects interviewed in the UK expressed a nearly 50-percent preference for full scientific reports over PowerPoint-type slide presentations, summary reports and Q&As/FAQs in that order, and roughly equal preference for these other three types of tools.

Subjects interviewed in Spain expressed a similar, marked preference for full scientific reports, and again approximately equal preference for the remaining three tools, although the order of the latter three differed slightly from that seen among UK subjects.

In addition to these main communications tools, a few subjects mentioned peer-reviewed scientific papers as useful for conveying information on air pollution and health.

While just a handful of subjects greatly preferred a given communications tool over all the rest, most ranked at least one other tool as having the same or nearly equal usefulness to them. And many said they would use more than one type of tool, either for themselves alone or for both themselves and pass-on users.

This means it is important that the Apheis centers provide virtually every user with more than one communications tool.

Concerning specific tools, many subjects said they want a high level of scientific detail and have the time to read full scientific reports, reflecting the general preference for such reports.

A substantial number of others, however, said they or their pass-on users simply don't have the time or desire to read an entire scientific report and digest the complex information it contains. Such users include government officials and many scientists who are inundated with scientific information. Subjects said this type of user prefers receiving a brief summary report or brochure that provides key information and facts, and references the main report for further details.

When commenting on slide presentations, many subjects emphasized their usefulness for conveying information to other participants in the policy-making process in a simple manner enabling many people in a room to grasp key facts, points and messages quickly and easily.

Subjects who liked Q&As/FAQs called them good tools for providing information in simple form on narrower subjects.

Finally, users who requested communications tools with a policy focus said they are generally not experts in the area of air pollution and health, or lack a scientific background. As a result, they rely on others to digest and distill the scientific information they need, translate it into nontechnical language they understand, frame it for their policy-making needs, explain what the findings and information mean, and highlight the benefits of taking specific types of action.

Based on the research findings, we determined that the following types of communications tools can best meet the different needs of the main audiences who require the information Apheis produces and who would use it in their work as policy influencers and makers for themselves and for their pass-on users in the policy-making chain:

- Complete scientific reports
- Summary scientific reports
- Peer-reviewed scientific papers
- Brochures with a policy focus
- PowerPoint presentations with a scientific focus
- PowerPoint presentations with a policy focus
- Q&As/FAQs with a scientific focus
- Q&As/FAQs with a policy focus

Because different audiences have different information needs, for each audience to get the information it wants in the form it wants it in, each Apheis center must first learn which of these tools best meet the needs of both direct and pass-on users in terms of content and form, and then use this knowledge to develop and provide tools tailored for each audience it wants to reach.

Following are what subjects told us are the main audiences for each of these communications tools, how these audiences use each tool, and what content and form they prefer for each. Knowledge of this information will help the Apheis centers better understand for whom they are developing each communications tool, and for what purpose members of each audience typically use the tools.

In terms of the information Apheis will provide, it should be noted that Apheis takes a multidisciplinary approach to the study of air pollution and its effects on health. And Apheis wishes to promote the exchange of know-how between public-health and environment professionals to achieve synergies and mutual enrichment of our respective work. Because of this integrated approach, our reports now provide information on both areas together, and will continue to do so.

Complete scientific report

Audiences for a complete scientific report include:

• Direct and pass-on scientific users, who use a complete scientific report as is, or may cut and paste sections of the report into other documents they create for their own use or that of others
• Policy pass-on users, who generally use a complete scientific report as a source to back up the information contained in shorter communications tools they pass on or who less frequently use the report as their primary source for decision making

The main features subjects told us they want in a complete scientific report include:

• A high level of scientific detail and complexity
• A clear, concise executive summary that highlights the report's key points
• A detailed description of the methodology used
• A clear presentation of the findings and their interpretation
• A set of clear conclusions
• A recent bibliography
• The use of charts, graphs and boxes to help readers absorb complex information at a glance, and help them find, understand and remember the report's key points

Summary scientific report

Audiences for a summary scientific report include:

• Direct and pass-on scientific users, both of whom use a summary scientific report to keep abreast of developments in various fields and of issues that are not necessarily central to their current work and with whose concepts they may not be familiar. Some use a summary scientific report as is. And some may cut and paste sections of it into other documents they create for their own use or that of others
• Policy pass-on users, who use the report as a source of summary information

The main features subjects told us they want in a summary scientific report include:

• A high level of scientific detail
• A clear, concise executive summary that highlights the report's key points
• A short description of the methodology used
• A set of clear conclusions
• A recent, short bibliography that enables users to obtain more complete data and analysis should they so desire
• The use of charts, graphs and boxes to help readers absorb complex information at a glance, and help them find, understand and remember the report's key points
• A total length of only a few pages

Peer-reviewed scientific papers

Audiences for peer-reviewed scientific papers include:

• Direct and pass-on scientific users, who use peer-reviewed scientific papers as is, or may cut and paste sections of the papers into other documents they create for their own use or that of others
• Policy pass-on users who are not experts on air pollution and health and who will use the papers to back up the information contained in shorter communications tools they pass on or use as their primary sources for decision making

The main features subjects told us they want in peer-reviewed scientific papers include:

• A clear, concise abstract that highlights key points
• A clear presentation of the objectives, methodology, findings, discussion and conclusions
• A recent bibliography
• The use of tables and graphs

Brochures with a policy focus

Audiences for brochures with a policy focus include:

• Policy pass-on users who are not experts on air pollution and health and require information they can grasp quickly and easily. Some use brochures with a policy focus as is, while others may cut and paste sections of these brochures into other documents they create for their own use or that of others

The main features subjects told us they want in a brochure with a policy focus include:

• A clear, concise executive summary that highlights key points
• Information presented in a simplified manner using easy-to-understand terms whose meanings are clearly defined
• A reduced level of scientific detail and complexity
• A few key messages presented simply and clearly with the help of bullet points, and of simple graphs, charts and/or tables
• Information framed and interpreted in terms relevant to policy-making needs
• A recent, short bibliography that enables users to obtain more complete data and analysis should they so desire
• A total length of only a few pages

PowerPoint presentations with a scientific focus

Audiences for PowerPoint presentations with a scientific focus include:

• Direct and pass-on scientific users who need to send and receive scientific information in a form that is easy to understand and digest. Some use a PowerPoint presentation with a scientific focus as is, while others may cut and paste sections of the presentation into other documents they create for their own use or that of others. They all use presentations to convey information at meetings, conferences and other gatherings

The main features subjects told us they want in a PowerPoint presentation with a scientific focus include:
• A summary of key findings
• A high level of scientific detail and complexity
• Content that is easy to understand and digest
• A recent bibliography

PowerPoint presentations with a policy focus

Audiences for PowerPoint presentations with a policy focus include:

• Policy pass-on users who are not experts on air pollution and health and require information they can grasp quickly and easily. Some use a PowerPoint presentation with a policy focus as is, while others may cut and paste sections of the presentation into other documents they create for their own use or that of others. They all use presentations to convey information at meetings, conferences and other gatherings

The main features subjects told us they want in a PowerPoint presentation with a policy focus include:

• A reduced level of scientific detail and complexity
• A few key messages presented simply and clearly in easy-to-understand terms using bullet points and supported, when appropriate, by simple graphs, charts and/or tables
• Information framed and interpreted in terms relevant to their policy-making needs
• A recent, short bibliography that enables users to obtain more complete data and analysis should they so desire

Q&As/FAQs with a scientific focus

Audiences for Q&As/FAQs with a scientific focus include:

• Direct and pass-on scientific users, and policy pass-on users, all of whom use Q&As/FAQs as a source of information for their own use
• Policy pass-on users who are not experts on air pollution and health and who will use the Q&As/FAQs to back up the information contained in shorter communications tools they pass on or use as their primary sources for decision making

The main features subjects told us they want in Q&As/FAQs with a scientific focus include:

• A high level of scientific detail and complexity
• A discussion of methodology issues
• A discussion of uncertainties
• A recent bibliography

Q&As/FAQs with a policy focus

Audiences for Q&As/FAQs with a policy focus include:

• Policy pass-on users who are not experts on air pollution and health and require information they can grasp quickly and easily. Some use Q&As/FAQs with a policy focus as is, while others may cut and paste sections of Q&As/FAQs into other documents they create for their own use or that of others

The main features subjects told us they want in Q&As/FAQs with a policy focus include:

• A clear, concise executive summary that highlights key points
• A reduced level of scientific detail and complexity
• Information framed and interpreted in terms relevant to their policy-making needs
• Simple, nonscientific discussions
• Uncertainties presented in a clear, simple manner
• A recent, short bibliography

How can we now develop these communications tools?

In its current phase, the Apheis programme sought to identify the information needs of its target communications audiences.

In its next phase, the Apheis programme will draw on the learnings of the Apheis Communications Strategy Project to develop the communications tools described above in a generic form that the individual Apheis centers can then adapt to their local needs.

To develop the tools, Apheis plans to retain the services of a communications professional who will work closely with those individuals best able to provide the scientific content needed for each tool and its audience or audiences.

What will the Apheis centers do next?

The Apheis centers can use the generic communications tools we will develop as is, translate them into their local languages and disseminate them.

However, to reach each Apheis audience as effectively and efficiently as possible, the centers should adapt the tools to local needs and conditions.

For this purpose, each center should first ascertain that its target audiences share information needs similar to those we have identified in terms of content and form.

To do this, we recommend that each center conduct a smaller version of the research we have done when developing the Apheis communications strategy. In particular, each center should survey those individuals with whom it is in contact who influence policy making directly or indirectly to determine both their information needs in terms of content and form, and the corresponding needs of those pass-on users who play a critical role in policy making but to whom the Apheis centers have little or no direct access.

Based on this information and its analysis, each Apheis center should then take the generic communications tools Apheis will produce, and tailor them to local information needs; local awareness of air-pollution levels and of their impact on health; local environmental and public-health conditions; local health and policy issues; and local ways of communicating.

Once the centers have localized the communications tools Apheis will provide, each center will need to get the tools tailored to the needs of pass-on users into the hands of those people who have access to pass-on users.

For this purpose, the centers should again use the information they obtain from those individuals with whom they are in contact who influence policy directly or indirectly to determine what tools they should give them to pass on to others closer to policy advisors and makers.

By completing these two steps, the Apheis centers can best ensure that their work reaches the key people who influence and make policy on air pollution throughout Europe, so that our work makes the greatest possible contribution to reducing air pollution and to improving health.

Working group

Michael Saklad at Saklad Consultants, Paris, designed the Apheis Communications Strategy Project, supervised its execution, reanalyzed the findings (with the help of Sylvia Medina for scientific aspects), and wrote this Summary Report.

Rene van Bavel, at the London School of Economics, and Lucia Sell-Trujillo conducted the interviews, and analyzed and reported on the information gathered.

Sylvia Medina and Antoni Plasència, co-managers of the Apheis programme, supervised the project.

Apheis would like to thank the many people who took time from their work to be interviewed for this project and to contribute to it.

More detailed information on the design of this project can be found in the following two documents:

- "Developing an Apheis Communications Strategy," prepared by Michael Saklad, Saklad Consultants (Appendix 1).
- "Description of Tasks, Apheis Communications Strategy Project," prepared by Michael Saklad, Saklad Consultants (Appendix 2).

More detailed information on the project's fieldwork can be found in:

- "Apheis Communications Strategy project: Draft Fieldwork Report," prepared by Rene van Bavel, London School of Economics.

To obtain this information, please write to Dr. Sylvia Medina, French Institute of Public Health Surveillance (InVS), 12 rue du Val d'Osne, 94415 Saint Maurice Cedex, France.

Health Impact Assessment

Key HIA findings

This report sought to analyse the impact of air pollution on public health in 26 cities in 12 European countries as part of the ongoing work of the Apheis programme.

This Apheis-3 phase added further evidence to the finding in Apheis-2 that air pollution continues to pose a significant threat to public health in urban environments in Europe.

In particular, concerning the ability of Apheis cities across Europe to meet future standards designed to reduce the impact of air pollution on health, Apheis-3 determined that, while most of the 26 cities studied met the annual mean cut-off of 40 µg/m^3 set as the limit value for PM_{10} to be reached by all member states of the European Union by 2005, 21 cities still exceeded the 2010 limit value of 20 µg/m^3. Nonetheless, nine cities nearly met the latter value.

Concerning the impact of exposure to PM_{10} in the very short, short and long terms, in the 23 Apheis cities that measured PM_{10}, totalling almost 36 million inhabitants, if all other things were equal and exposure to outdoor concentrations of raw PM_{10}[1] were reduced to 20 µg/m^3 in each city, 2 580 premature deaths, including 1 741 cardiovascular and 429 respiratory deaths, could be prevented annually if the impact is only estimated over a very short term of 2 days. The short-term impact, cumulated over 40 days, would be more than twice as great, totalling 5 240 premature deaths prevented annually, including 3 458 cardiovascular and 1 348 respiratory deaths. And the long-term impact[2] over several years would be even higher, totalling 21 828 premature deaths prevented annually.

Apheis-3 also contributed the following significant findings:

For both total and cause-specific mortality, the benefit of reducing converted $PM_{2.5}$[3] levels to 15 µg/m^3 is more than 30 % greater than for a reduction to 20 µg/m^3. Moreover, even at 15 µg/m^3 a significant health impact can be expected.

[1] For HIAs of short-term exposure, we used raw PM_{10} and BS levels measured directly at monitoring stations.
[2] For HIAs of long-term exposure, we had to correct the automatic PM_{10} measurements used by most of the cities by a specific correction factor (local or, by default, the European factor of 1.3) in order to compensate for losses of volatile particulate matter
[3] For most of the cities, $PM_{2.5}$ measurements were not available, and $PM_{2.5}$ levels had to be calculated from PM_{10} measurements. For this purpose a conversion factor (local or, by default, the European factor of 0.7) was used.

In specific, the Apheis-3 HIA estimated that 11 375 “premature” deaths, including 8 053 cardiopulmonary deaths and 1 296 lung-cancer deaths, could be prevented annually if long-term exposure to the annual mean of converted $PM_{2.5}$ levels were reduced to 20 µg/m^3 in each city; and that 16 926 premature deaths, including 11 612 cardiopulmonary deaths and 1 901 lung-cancer deaths, could be prevented annually if long-term exposure to converted $PM_{2.5}$ were reduced to 15 µg/m^3.

In terms of life expectancy, if all other things were equal and the annual mean of $PM_{2.5}$ converted from PM_{10}[4] did not exceed 15 µg/m^3 the potential gain in life expectancy of a 30-year-old person would average between 2 and 13 months, due to the reduction in total mortality.

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Black smoke is often considered a good proxy for traffic-related air pollution. In the 16 cities that measured BS, which total over 24 million inhabitants, if all other things were equal and BS levels were reduced to a 24-hour value of 20 µg/m^3, 1 296 total “premature” deaths including 405 cardiovascular deaths and 109 respiratory deaths, could be prevented annually.

In the Apheis cities, particulate pollution contributed in a non-negligible manner to the total burden of mortality as follows:

- All other things being equal, when only considering very short-term exposure, the proportion of all-causes mortality attributable to a reduction to 20 µg/m^3 in raw PM_{10} levels would be 0.9% of the total burden of mortality in the cities measuring PM_{10}. This proportion would be greater, 1.8%, for a cumulative short-term exposure up to 40 days. Effects of long-term reduction in corrected PM_{10} levels would account for 7.2% of the burden of mortality.
- For BS, only very short-term exposure (raw levels) was considered. All other things being equal, the proportion of all-causes mortality attributable to a reduction to 20 µg/m^3 in BS levels would be 0.7% of the total burden of mortality.
- For long-term exposure to $PM_{2.5}$ converted from corrected PM_{10}, all other things being equal the proportion of all-causes mortality attributable to a reduction to 20 µg/m^3 in converted $PM_{2.5}$ levels would be 4% of the total burden of mortality.

In order to provide a conservative overall picture of the impact of urban air pollution on public health in Europe, like its predecessor Apheis-2 the Apheis-3 phase used a limited number of air pollutants and health outcomes for its HIAs. Apheis-3 also established a good

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[4] For most of the cities, $PM_{2.5}$ measurements were not available, and $PM_{2.5}$ levels had to be calculated from PM_{10} measurements. For this purpose a conversion factor (local or, by default, the European factor of 0.7) was used.

basis for comparing methods and findings between cities, and explored important HIA methodological issues.

Our findings add further support to WHO's view that "it is reasonable to assume that a reduction of air pollution will lead to considerable health benefits." And, at least for particulate pollution, our findings support WHO's already strong recommendation for "further policy action to reduce levels of air pollutants including PM, NO_2 and ozone"(WHO 2004).

Introduction

The information Apheis provides is based on HIA. In the field of air pollution, an HIA can play a role in evaluating different policy scenarios for reducing air-pollution levels; in assessing new air-quality directives; or in calculating the external monetary costs of air pollution or the benefits of preventive actions.

Apheis HIAs aim to provide the number of health events that could be prevented (or the gain in life expectancy) from air pollution in the target population. This enables evaluating different policy scenarios for reducing air-pollution levels and helps to assess new air-quality directives. For the time being, Apheis does not calculate the external monetary costs of air pollution or the benefits of preventive actions.

Apheis-3 updated the HIAs and provided new indicators of particles, new health outcomes and, in addition to the absolute number of cases, life-expectancy findings to estimate the health impacts of long-term exposure to particulate pollution.

Methods

HIA methodology

Apheis-3 followed the recommendations of the WHO Guidelines on the Assessment and Use of Epidemiological Evidence for Environmental Health Risk Assessment (WHO 2000, 2001):

- "Specify exposure. If exposure represents a mixture, the selection of the most reasonable indicator(s) of the mixture has to be discussed. Attention should be paid to the time dimension of exposure (averaging times and duration). The distribution of exposure in the target population and in the epidemiological studies used to derive the exposure-response functions should be coherent. The magnitude of the impact depends on the level and range of exposure for which HIA is required to estimate the number of cases. The choice of a reference level may consider epidemiological and other data with regard to issues such as the existence of thresholds and natural background levels. If exposures in the target population exceed or are below those studied, it will be necessary to determine whether exposure-response functions should be extrapolated or not."

- "Define the appropriate health outcomes. The purpose of the HIA, the definition of exposure and the availability of the necessary data will guide the selection of outcomes. In some cases, the HIA should be assessed separately for each health outcome for which there is evidence of an effect. In other cases, in particular when estimating the monetary costs, we should avoid overlapping of various health outcomes."

- "Specify the exposure-response relationship. The exposure-response function is the key contribution of epidemiology to HIA. The function may be reported as a slope of a regression line or as a relative risk for a given change in exposure. Exposure-response functions may be derived from pooled analysis or published meta-analyses."

- "Derive population baseline frequency measures for the health outcomes under consideration. This is to quantify the prevalence or incidence of the selected outcomes. This information should preferably be obtained from the target population for which HIA is being made."

- "Calculate the number of cases, under the assumption that exposure causes the health outcome, based on the distribution of the exposure in the target population, the estimates of the epidemiology exposure-response function and the observed baseline frequency of the health outcome in the population."

Data collection and exposure-response functions

For the present HIA, Apheis has analysed the acute effects of PM_{10} and BS on premature mortality and hospital admissions. We also estimated the impacts on premature mortality of long-term exposure to PM_{10} and $PM_{2.5}$.

Air pollution indicators: Particulate matter

Air pollution is a complex mixture of various substances. However, most epidemiological studies find a range of health outcomes to be consistently related to particulate matter. A recent WHO review (WHO 2003) concludes that ambient PM per se is considered responsible for the health effects seen in large epidemiological studies relating ambient PM to mortality and morbidity. This conclusion is also supported by toxicological evidence. These epidemiological studies provide exposure-response functions necessary for HIA. In its first HIA, Apheis chose PM_{10} and BS as particulate-matter indicators. In the HIA presented below, $PM_{2.5}$ was also included based on recent evidence (WHO, 2003, 2004) and on the status of $PM_{2.5}$ within the EC legislation process (Appendix 11).

Exposure measurements

In order to harmonise and compare the information relevant to exposure assessment provided by the 26 Apheis cities, the Apheis Exposure Assessment Advisory Group prepared a questionnaire to assess the cities' fulfilment of the Apheis guidelines on exposure assessment. A full description of the exposure assessment in each city appears in Appendix 3. The description includes: the total number and type of monitoring stations and the number used for HIA purposes; the measurement methods and the use of a correction and/or conversion factors; the quality assurance and control and data quality.

Considerations regarding PM measurements

PM_{10} correction factor

For the purpose of long-term HIA only, not for short-term, because the exposure-response functions used are taken from publications that used gravimetric methods (Künzli et al. 2000, and Pope et al. 2002), to be consistent we decided to correct the automatic PM_{10} measurements (ß-attenuation and TEOM) used by most of the cities by a specific correction factor in order to compensate losses of volatile particulate matter. A local correction factor chosen with the advice of the local air-pollution network was used when available; otherwise, the cities used the 1.3 European default correction factor recommended by the EC Working Group on Particulate Matter (**http://europa.eu.int/comm/environment/air/pdf/finalwgreporten.pdf**) (see Table 1 and Appendix 3 for more details).

$PM_{2.5}$ conversion factor

For most of the cities, $PM_{2.5}$ measurements were not available and the cities had to estimate $PM_{2.5}$ data from PM_{10} measurements. For this purpose they used a conversion factor, also for long-term HIA only. If available, a local conversion factor (ranging between 0.5 and 0.8), selected with the advise of the local air-monitoring network was applied. If no local factor was available, 0.7 was used as default conversion factor. The default factor of 0.7 was recommended by the Apheis Exposure Assessment Working Group as a mean value based on two different, recent publications. First, within the process of the revision and update of the so-called 1st European Daughter Directive, the 2nd Position Paper on Particulate Matter (draft of 20 August 2003, available for the PM Meeting in Stockholm) presents the results from 72 European locations reported by several Member states from 2001. It gives $PM_{2.5}/PM_{10} = 0.65$ (range 0.42-0.82, se = 0.09). Second, Van Dingeren et al. 2004 recently published a European research activity, with a smaller number of stations (11 stations), giving the ratio = 0.73, se = 0.15 (range 0.57-0.85) (see Table 1 and Appendix 3 for more details).

Total suspended particulates (TSP) conversion factor

Only two cities, Bucharest and Budapest, evaluated 12 TSP monitoring stations (7%) as appropriate for HIA. They converted TSP to PM_{10}, using respectively 0.6 and 0.58 as local conversion factors.

Table 1. Measurement methods, correction and conversion factors used in Apheis-3

City	Measurement method				PM_{10} correction factor	Conversion factor from PM_{10} to $PM_{2.5}$
	PM_{10}	$PM_{2.5}$	Black smoke	TSP[1]		
Athens	ß-attenuation		reflectometry		1.3*	0.3-0.63***[2]
Barcelona			normalised smoke		not applicable	not applicable
Bilbao	ß-radiation absorption		reflectometry		1.2[#]	0.7**
Bordeaux	TEOM (50°C)	TEOM (50°C)	reflectometry		1s; 1.3w	0.67***
Bucharest				gravimetric	[x]	0.7**
Budapest				ß-ray-operation	[xx]	0.7**
Celje	TEOM (50°C)		reflectometry		1.3*	0.7**
Cracow	ß-gauge-monitor		reflectometry		1.25#	0.8***
Dublin			reflectometry		not applicable	not applicable
Gothenburg	TEOM (50°C)	TEOM (50°C)			1.3*	0.66***
Le Havre	TEOM (50°C)	TEOM (50°C)	reflectometry		1[s]; 1.253[w]	0.7**
Lille	TEOM (50°C)	TEOM (50°C)	reflectometry		1.18[s]; 1.27[w]	0,66***
Ljubljana	TEOM (50°C)		reflectometry		1.3*	0.7
London	TEOM	TEOM	reflectometry		1.3	0.7
Lyon	TEOM		reflectometry		1.221[w]	0.7**
Madrid	ß-attenuation				1[#]	0.51***
Marseille	TEOM (50°C)	TEOM (50°C)	reflectometry		1s; 1.13w	0.65***
Paris	TEOM	TEOM	reflectometry		1[s]; 1.37[w]	0.7**
Rome	ß-gauge monitor				1.3*	0.7**
Rouen	TEOM (50°C)	TEOM (50°C)	reflectometry		1[s]; 1.22[w]	0.7**
Seville	ß-radiation-attenuation				1.13[#]	0.7**
Stockholm	TEOM (50°C)	TEOM (50°C)			1.2[#]	0.65***
Strasbourg	TEOM (50°C)	TEOM (50°C)			1[s]; 1.21[w]	0.7**
Tel Aviv	TEOM				1.3*	0.5***
Toulouse	TEOM (50°C)	TEOM (50°C)			1s; 1.2w	0.65***
Valencia			reflectometry		not applicable	not applicable

* For HIA purpose PM10 TEOM has been corrected by a European default factor of 1.3 from the EC working group on Particulate Matter

** To convert PM_{10} to $PM_{2.5}$ the European default conversion factor 0.7 was used

***To convert PM10 to PM2.5 a local conversion factor was used

[#]: derived from parallel PM_{10} measurements within the city

1. TSP: total suspended particulates

2. Range of PM2.5 conversion factor, because month-specific factors were used

[s]: summer

[w]: winter

[X] PM10=TSP*0.6

[XX] PM10=TSP*0.58

Health outcomes and E-R functions

HIAs for short-term exposure

For comparison purposes, and to provide a better understanding of the effects of particulate pollution on health over time, HIAs on the effects of short-term exposure used two types of exposure-response functions: for a very short exposure (usually 1 or 2 days) and for a cumulative exposure (up to 40 days):

- for the very short exposure, we used a new exposure-response function developed by Apheis-3 for all-ages respiratory admissions (Appendix 4). We also used exposure-response functions newly developed by WHO as a result of a meta-analysis of time series and panel studies of particulate matter (PM). The calculations were done by a group of experts at St. George's Hospital in London, UK, guided by a WHO task group. The WHO report is available at the following address: **http://www.euro.who.int/document/E82792.pdf**

- for a cumulative short-term exposure, Zanobetti et al. examined up to 40 days of follow-up for all causes (Zanobetti et al, 2002) and cardiovascular and respiratory deaths (Zanobetti et al, 2003) in the APHEA-2 study. Zanobetti's report showed the cumulative effect was more than twice that found using only 2 days of follow-up. Then, for Apheis-3, we also used Zanobetti's estimates using distributed-lag models.

The following health outcomes were selected, based on the availability of the E-R functions:

- Total premature mortality, excluding accidents and violent deaths
- Cardiovascular mortality
- Respiratory mortality
- Cardiac hospital admissions
- Respiratory hospital admissions

Most HIAs, including Apheis HIAs, use overall estimates from multi-centre studies. However some people who conduct an HIA in a particular city where an epidemiological study has been conducted providing local E-R functions prefer to use city-specific estimates. Apheis has discussed the issue of using city-specific estimates, and the Statistical Advisory Group conducted a sensitivity analysis using different effect estimates (Appendix 5). Consequently, additional HIAs comparing the use of these estimates were conducted for some cities that are also part of the APHEA-2 project,

HIAs for long-term exposure

Apheis-3 conducted HIAs on the effects of long-term exposure in terms of number of cases for PM_{10} and $PM_{2.5}$ and in terms of reduction in life expectancy for $PM_{2.5}$.

Based on the availability of the exposure-response functions:

- For long-term exposure to PM_{10}, we estimated the impact on premature mortality using the E-R function already applied in Apheis-2. This E-R function is based on the first ACS study and on the Six Cities Study and was used in the HIA conducted in Austria, France and Switzerland (Kunzli et al., 2000).
- For long-term exposure to $PM_{2.5}$, we used average estimates of the more recent ACS study based on the average $PM_{2.5}$ (Pope, 2002), and the health outcomes were studied for all-causes mortality, cardiopulmonary mortality and lung-cancer mortality.

Appendix 6 gives a full description of the health indicators used for this new phase of Apheis, including the types of sources, the coverage, the existence of a quality-control programme, the type of coding used, the completeness of the data, and conclusions about the comparability of the data.

HIA tools: PSAS-9 Excel spreadsheet and AirQ

Number of short and long-term cases

Calculations of the number of short and long-term cases were made using an Excel spreadsheet (Appendix 7) developed by the French surveillance system on air pollution and health, called the PSAS-9 programme coordinated by InVS, the French Institute of Public Health Surveillance (**http://www.invs.sante.fr/psas9**).

An estimate of the impact can be based on the calculation of the attributable proportion (AP), indicating the fraction of the health outcome that can be attributed to the exposure in a given population (provided there is a causal association between the exposure and the health outcome). With the population distribution of exposure determined in the exposure assessment stage, and the identified E-R function, the attributable proportion can be calculated using the formula:

$$AP = \Sigma \{ [RR(c) - 1] \times p(c)\} / \Sigma [RR(c) \times p(c)] \quad [1]$$

where: RR(c) is the relative risk for the health outcome in category c of exposure

p(c) is the proportion of the target population in category c of exposure

Knowing (or, often, assuming) a certain underlying frequency of the outcome in the population, I, the rate (or number of cases per unit population) attributed to the exposure in the population can be calculated as:

$$IE = I \times AP$$

Consequently, the frequency of the outcome in the population free from the exposure can be estimated as:

$$INE = I – IE = I \times (1 – AP) \quad [2]$$

For a population of a given size N, this can be converted to the estimated number of cases attributed to the exposure, NE = IE X N.

Knowing the (estimated) incidence among the non-exposed population and the relative risk at a certain pollution level, it is also possible to estimate an excess incidence (I+(c)) and excess number of cases (N+(c)), at a certain category of exposure:

$$I+(c) = (RR(c) - 1) \times p(c) \times INE \quad [3]$$

$$N+(c) = I+(c) \times N \quad [4]$$

Gain in life expectancy and years of life lost

We calculated gain in life expectancy and years of life lost using the WHO-ECEH Air Quality Health Impact Assessment software (AirQ) (Appendix 8) (**http://www.euro.who.int/eprise/main/WHO/Progs/AIQ/Activities/20040428_2**).

The "life tables" module of AirQ calculates the health effects attributable to changes in long-term exposure to air pollution. The assessment uses evidence generated by epidemiological cohort studies showing an increase in the mortality risk in populations living in areas with a higher than average long-term air-pollution level. The underlying assumption of the procedure is the applicability of relative risk estimates and of the exposure-response function estimated in epidemiological studies (evidentiary population) in the target population.

The observed age structure of the population and age-specific mortality data are used to calculate the number of survivals and number of "premature" deaths in each age category in future years. The difference between the survival functions of the population at risk due to increased pollution and without risk enables calculating several parameters of impact. The program displays selected parameters (reduction of life expectancy at certain age, loss of expected years of life due to "premature" deaths in 1 year, years of life lost in 1 year or in the entire period of follow-up due to the risk factor).

The program can calculate changes in survival related to the impact of the pollution on all causes of death or on one (or two) of the selected specific causes of death (cardiovascular disease and lung cancers).

Calculations can be based on the risk coefficients provided by the user or on the WHO default values. The present version uses the risk coefficients for $PM_{2.5}$ from the American Cancer Society cohort study (Pope CA, Burnett RT, Thun MJ, Calle EE, Krewski D, Ito K, Thurston G. Lung Cancer, Cardiopulmonary Mortality, and Long-term Exposure to Fine Particulate Air Pollution. JAMA 2002; 287(9):1132-1141).

Life expectancy

Life-expectancy calculations are based on the following considerations: the survival curve for a birth cohort predicts the temporal pattern of deaths in the cohort. Expected life from birth can be calculated by summing the life years over all period and dividing by the size of the starting population. Conditional expectation of life, given achieving a certain age, can also be calculated by summing the years of life at that age and later, and dividing by the number achieving that age (Miller BG in WHO, 2001).

Life expectancy with zero mortality for one cause can be used to indicate the relative importance of an illness. A life table is calculated assuming the complete elimination of a particular cause, and the resulting hypothetical life expectancy is compared with the actual life expectancy (Romeder and McWhinnie, 1977). The greater is the difference, the greater is the relative importance of the cause. In air pollution health impact assessment, a similar approach can be used, and actual life expectancy can be compared with the hypothetical life expectancy obtained for the baseline scenario. For that purpose, hazard rates must be predicted in the baseline scenario. Apheis it has been assumed the same proportional hazard reduction for every age group (age > 30), and we calculated hazard rates of the baseline scenario by dividing the actual hazard rates by the corresponding relative risk (RR).

Years of life lost

With the AirQ software version 2.2, long-term effects of air pollution can be assessed by calculating years of life loss (YoLL) in a population exposed to a certain level of air pollution for a specified time period. YoLL can thus be attributable to this specific population exposure, all other factors being stable over the specified time period. “Years of life lost for starting year of simulation” compares the absolute numbers of YoLL based on the initial distribution (Appendix 8).

In Apheis-3, YoLL findings are displayed in each city report. In this, the main report we chose to present the gain in life expectancy.

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Compilation of findings

Descriptive findings

A summary of Apheis-2 findings appears in Appendix 9. In this new phase, air pollution data (Table 2) was available for 2000 and beyond in all the cities, except Tel Aviv. Demographic and health data were also available for 2000 and beyond in most of the cities, except French cities, Seville and Tel Aviv.

Table 2. Years for air pollution and health data in Apheis-3

City	Air pollution data			Health data	
	BS	PM_{10}	$PM_{2.5}$	Mortality	Hospital admissions
Athens	2001	2001	$PM_{2.5}$ converted from PM_{10}	2001	
Barcelona	2000			2000	2000
Bilbao	2002	2002	$PM_{2.5}$ converted from PM_{10}	2001	2001
Bordeaux	2002	2000	2002	1999	2000
Bucharest		2000 PM_{10} converted from TSP	$PM_{2.5}$ converted from PM_{10}	2000	
Budapest		2000 PM_{10} converted from TSP	$PM_{2.5}$ converted from PM_{10}	2000	2000
Celje	2000	2000	$PM_{2.5}$ converted from PM_{10}	2000	2000
Cracow	2000	2000	$PM_{2.5}$ converted from PM_{10}	2000	
Dublin	2000			2000	
Gothenburg		2000	2000	2000	2000
Le Havre	2000	2000	2002	1999	2000
Lille	2001	2001	2001	1999	2001
Ljubljana	2000	2000	$PM_{2.5}$ converted from PM_{10}	2000	2000
London	2001	2001	2001	2001	2001
Lyon	2001	2000	$PM_{2.5}$ converted from PM_{10}	1999	2000
Madrid		2000	$PM_{2.5}$ converted from PM_{10}	2000	2001
Marseille	2000	2000	2002	1999	2001
Paris	2000	2000	2000	1999	2001
Rome		2001	$PM_{2.5}$ converted from PM_{10}	2001	2001
Rouen	2001	2001	2002	1999	2000
Seville		2000	$PM_{2.5}$ converted from PM_{10}	2000	1999
Stockholm		2000	2000	2000	2000
Strasbourg		2002	2002	1999	2000
Tel Aviv		1998	$PM_{2.5}$ converted from PM_{10}	1998	1998
Toulouse		2000	2000	1999	2000
Valencia	2000			2000	2000

Demographic characteristics

The total population of almost 39 million inhabitants covered by Apheis-3 is comparable to the previous one covered by the Apheis-2 phase. The proportion of people over 60 years of age has increased 1% over Apheis-2 findings, ranging from 12.8% in Dublin and Lille to 21.9% in Barcelona (Table 3).

Table 3. Demographic characteristics

City	Year	Population	Population over 65 years
		Number	Percent
Athens	2001	3 188 305	15.9
Barcelona	2000	1 512 971	21.9
Bilbao	2001	708 395	19.3
Bordeaux	1999	584 164	15.8
Bucharest	2000	2 009 200	13.0
Budapest	2000	1 797 088	18.7
Celje	2000	48 943	14.9
Cracow	2000	737 927	13.6
Dublin	2002	495 781	12.8
Gothenburg	2000	462 470	16.4
Le Havre	1999	254 585	15.1
Lille	1999	1091156	12.8
Ljubljana	2000	263 290	20.9
London	2001	6 796 900	13.8
Lyon	1999	782 828	15.7
Madrid	2000	2 938 723	21.4
Marseille	1999	856 165	18.7
Paris	1999	6 164 418	13.2
Rome	2000	2 643 581	18.0
Rouen	1999	434 924	15.2
Seville	2000	700 715	13.9
Stockholm	2000	1 173 000	15.6
Strasbourg	1999	451 133	13.3
Tel Aviv	1998	1 139 360	15.0
Toulouse	1999	690 162	13.5
Valencia	2000	742 813	19.0

Air pollution levels

In our surveillance system, black smoke measurements were provided by 16 cities (including one more city than in Apheis-2: Lyon): Athens, Barcelona, Bilbao, Bordeaux, Celje, Cracow, Dublin, Le Havre, Lille, Ljubljana, Lyon, London, Marseille, Paris, Rouen and Valencia.

PM_{10} measurements were provided by 21 cities (including four more cities than in Apheis-2: Athens, Bilbao, Le Havre and Rouen): Athens, Bilbao, Bordeaux, Celje, Cracow, Gothenburg, Le Havre, Lille, Ljubljana, London, Lyon, Madrid, Marseille, Paris, Rome, Rouen, Seville, Stockholm, Strasbourg, Tel Aviv and Toulouse. Bucharest and Budapest converted TSP into PM_{10}.

For the first time in Apheis, $PM_{2.5}$ measurements were provided by 11 cities: Bordeaux, Gothenburg, Le Havre, Lille, London, Marseille, Paris, Rouen, Stockholm, Strasbourg and Toulouse. The other cities converted $PM_{2.5}$ from PM_{10}.

Some cities provided black smoke and/or PM_{10} and/or $PM_{2.5}$ measurements.

According to the European Council Directive 1999/30/EC of 22 April 1999 relating to limit values for sulphur dioxide, nitrogen dioxide and all nitrogen oxides, particulate matter and lead in ambient air (Official Journal L 163, 29/06/1999 P. 0041 – 0060), a PM_{10} 24-hour limit value of 50 $\mu g/m^3$ should not be exceeded more than 35 times per year by 1 January 2005 and no more than seven times per year by 1 January 2010 in the Member States. Also, a PM_{10} annual limit value should not exceed 40 $\mu g/m^3$ by 1 January 2005 and 20 $\mu g/m^3$ by 1 January 2010 (Appendix 10).

Table 4 and Figures 1, 2 and 3 give a broad picture of current observed levels of particulate pollution in the 26 cities (mean levels, standard deviation [SD], 5th and 95th percentiles of the distribution of the pollutant in each city). These levels are still not adjusted for HIA estimations. Table 7 provides the adjusted exposure levels for HIA on long-term exposure.

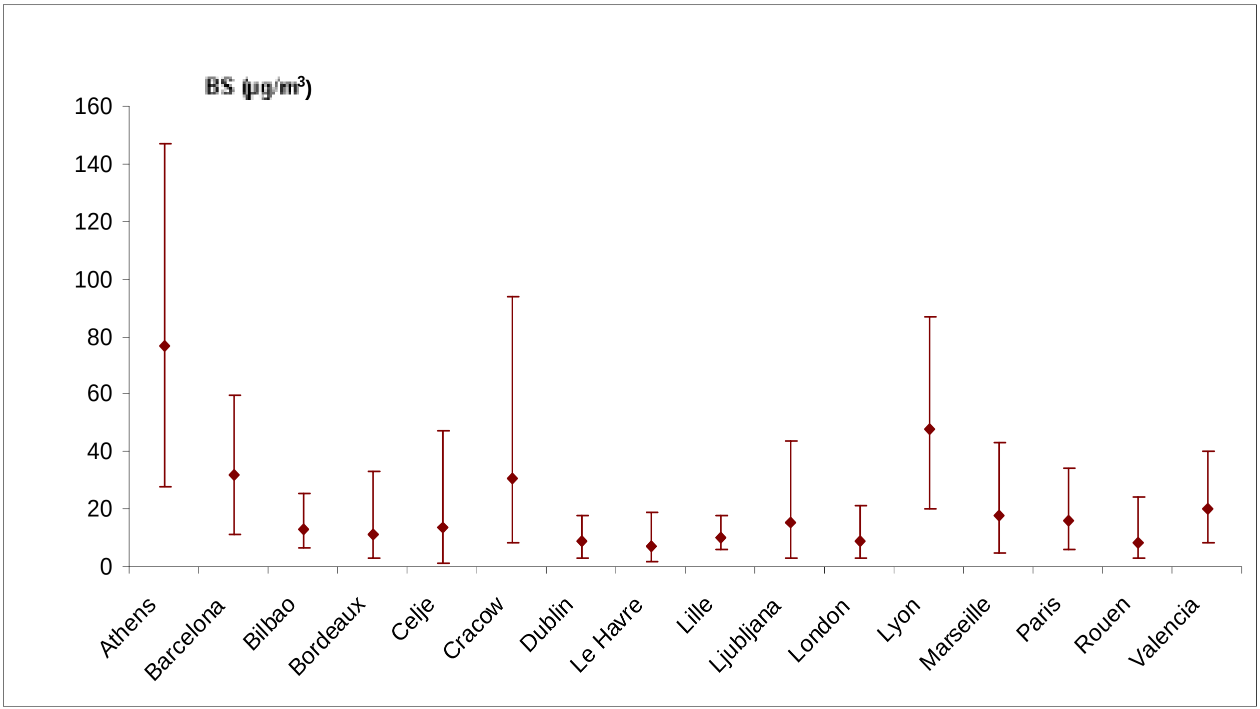
When reading these tables and figures, keep in mind the possible different sources of variability in the exposure measurements (see section "How to Interpret the Findings" and Appendix 3).

Table 4. Measured PM_{10}, $PM_{2.5}$ and BS levels ($\mu g/m^3$) in 26 Apheis cities.

City	Year	PM_{10}				$PM_{2.5}$				BS			
		Mean	SD[1]	P5[2]	P95[3]	Mean	SD	P5	P95	Mean	SD	P5	P95
Athens	2001	52	19	25	87					77	37	28	147
Barcelona	2000									32	13	11	59
Bilbao	2002	36	17	16	69					13	6	6	25
Bordeaux	2000/2002[4]	20	10	9	43	13	6	6	25	11	11	3	33
Bucharest[5]	2000	61	20	40	88								
Budapest[5]	2000	29	12	13	50								
Celje	2000	36	20	11	70					14	16	1	47
Cracow	2000	32	18	12	70					31	28	8	94
Dublin	2000									9	5	3	18
Gothenburg	2000	14	7	5	27	9	5	3	18				
Le Havre	2000/2002[4]	21	8	11	39	13	8	6	29	7	7	2	19
Lille	2001	21	12	10	39	16	11	7	31	10	4	6	18
Ljubljana	2000	32	24	4	72					15	17	3	44
London	2001	22	8	13	38	13	6	7	24	9	6	3	21
Lyon	2000/2001[4]	23	12	10	45					48	21	20	87
Madrid	2000	37	17	15	69								
Marseille	2000/2002[4]	27	10	13	42	18	8	8	33	18	13	5	43
Paris	2000	22	9	12	37	14	7	7	26	16	11	6	34
Rome	2001	47	17	25	77								
Rouen	2001/2002[4]	21	9	12	38	15	8	7	29	8	7	3	24
Seville	2000	44	12	27	65								
Stockholm	2000	14	7	7	29	9	4	5	18				
Strasbourg	2002	23	12	9	46	16	10	6	34				
Tel Aviv	1998	65	119	29	105								
Toulouse	2000	24	10	11	44	16	7	7	30				
Valencia	2000									20	11	8	40

1. SD: Standard deviation
2. P5: 5^{th} percentile of the distribution of the pollutant
3. P95: 95^{th} percentile of the distribution of the pollutant
4. For Bordeaux, year 2000 for PM_{10} and year 2002 for $PM_{2.5}$ and BS; for Le Havre and Marseille, year 2000 for PM_{10} and BS and year 2002 for $PM_{2.5}$; for Lyon, year 2000 for PM_{10} and year 2001 for BS; for Rouen, year 2001 for BS and PM_{10} and year 2002 for $PM_{2.5}$
5. PM_{10} converted from TSP

Figure 1. Annual mean levels and 5th and 95th percentiles of the distribution of black smoke (BS)



Compared to Apheis-2, Athens continues to show by far the highest mean levels of BS (77 µg/m^3). One of the reasons for these high levels may still be that the two selected stations measuring BS are in the centre of Athens and are characterized as traffic stations. Note that, all other things being equal, BS levels in this city increased by 17% (11 µg/m^3) between 1996 and 2001.

Lyon, Barcelona and Cracow follow with levels higher than 30 µg/m^3. Most of the cities showed a reduction in their BS levels. The lowest BS levels (below 10 µg/m^3) are seen in Dublin, Le Havre, London and Rouen.

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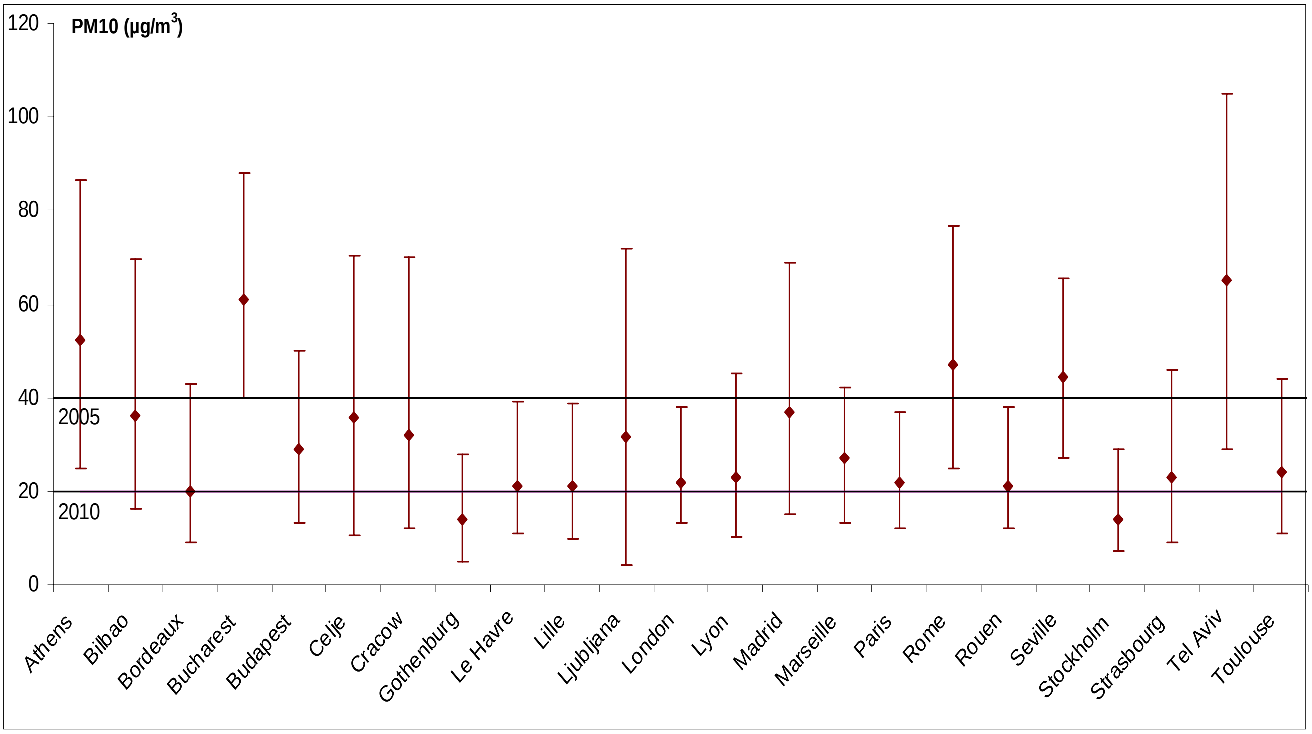
Figure 2. Annual mean levels and 5th and 95th percentiles of the distribution of PM_{10}



Horizontal lines indicate the European Commission (EC) PM_{10} annual mean cut-offs of 40 µg/m³ and 20 µg/m³ to be reached respectively in 2005 and 2010.

Tel Aviv shows the highest mean values of PM_{10} levels (65 µg/m³), partly influenced by wind-blown sand from the desert. All other things being equal, PM_{10} levels in this city increased by 15% (8.6 µg/m³) between 1996 and 1998.

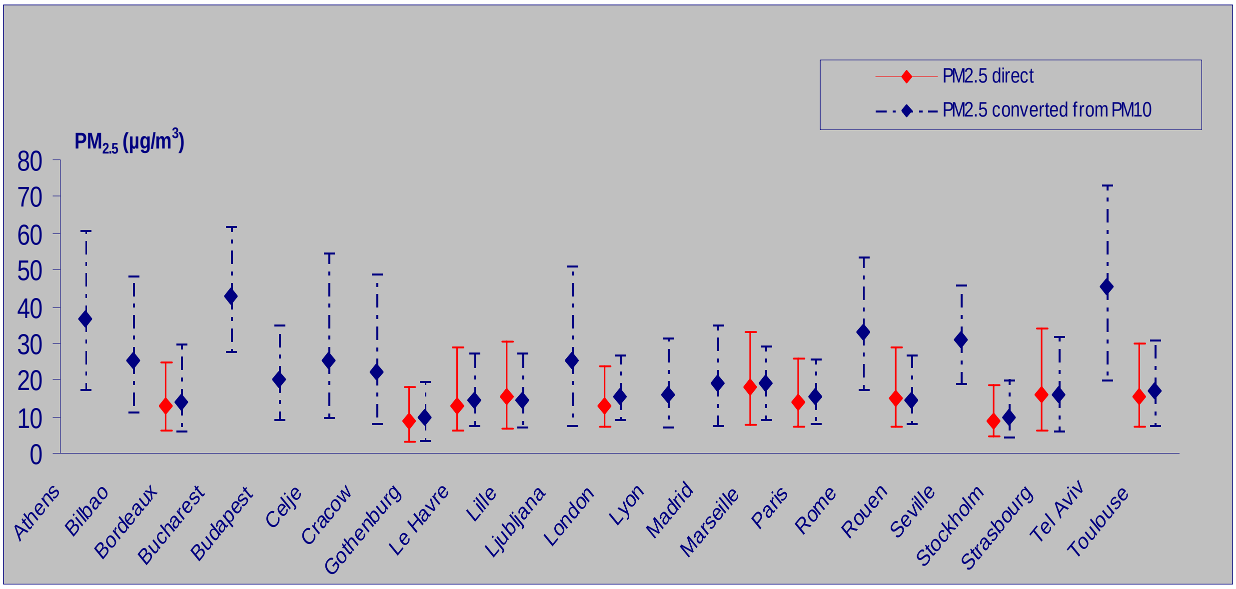
Bucharest continues to show high PM_{10} levels (61 µg/m³) but lower than in Apheis-2 (73 µg/m³). In this city measurements continue to be available for 4 weekdays (Monday to Thursday); this may explain the high levels observed.

Athens, which measures PM_{10} for the first time in Apheis, also shows quite high levels (52 µg/m³) in particular because four of the six stations that measure PM_{10} have been characterised as traffic stations.

Rome and Seville show PM_{10} levels higher than the PM_{10} annual limit value (40 µg/m³) not to be exceeded by 1 January 2005. Compared to Apheis-2, all other things being equal, Cracow is now below this limit, with most of the cities in the range between 40 and 20 µg/m³. Gothenburg and Stockholm continue to show levels below 20 µg/m³.

Again, it should be remembered that annual means of different years may have potential sources of variability in the measurements in the different cities (see section “How to Interpret the Findings” and Appendix 3).

Figure 3. Annual mean levels and 5th and 95th percentiles of the distribution of $PM_{2.5}$ direct and $PM_{2.5}$ converted from PM_{10} using the European conversion factor.



$PM_{2.5}$ direct measurements ranged between 9 µg/m^3 in Gothenburg and Stockholm and 18 µg/m^3 in Marseille.

In order to assess the local validity of the 0.7 European conversion factor from PM_{10} used in cities where a local conversion factor was not available, we asked those cities with both PM_{10} and $PM_{2.5}$ direct measurements to provide both direct $PM_{2.5}$ measurements and converted $PM_{2.5}$ using the European conversion factor.

Figure 3 shows that the converted $PM_{2.5}$ levels using the European conversion factor from PM_{10} are quite similar to the direct levels, although sometimes slightly higher than them. Levels of $PM_{2.5}$ converted from PM_{10} follow PM_{10} patterns.

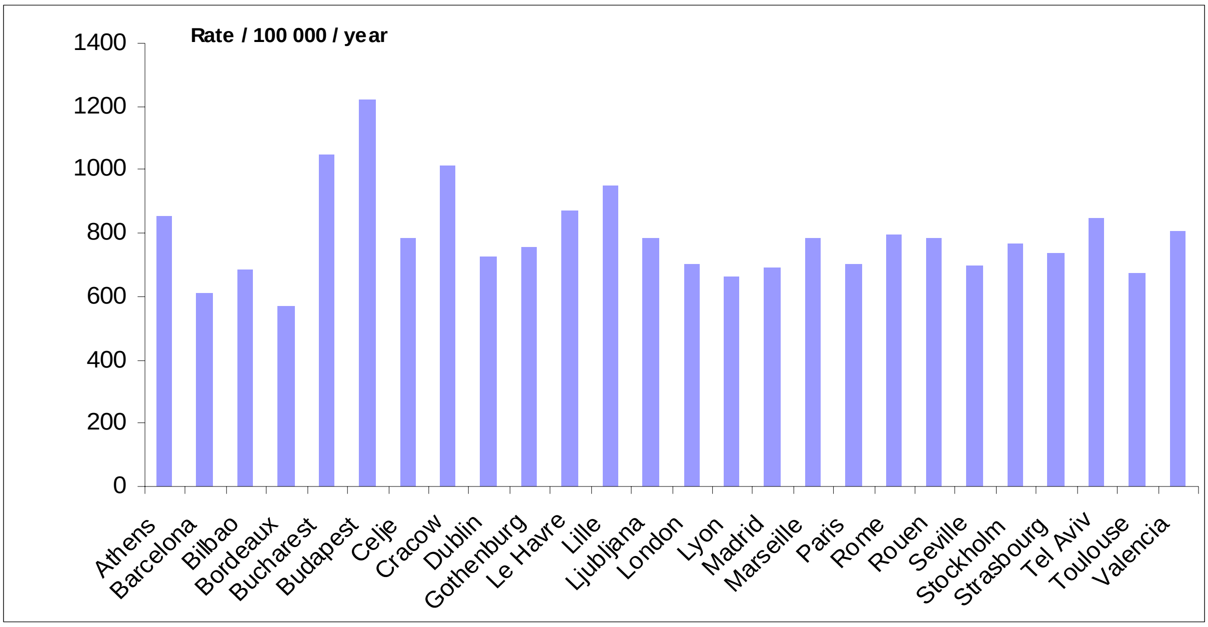
Please note that the bars are slightly shifted to the right.

Health indicators

Mortality

Figure 4 shows the standardised mortality rates for all causes of death, including violent causes, in the 26 cities. The highest rates are for Budapest, Bucharest and Cracow (over 1 000 per 100 000).

Figure 4. Age-standardised mortality rates for all causes of death in the 26 cities



Age-standardised mortality rate per 100 000 including violent deaths using the European population for 2000 year (United Nations, 2001)[5]

Hospital admissions

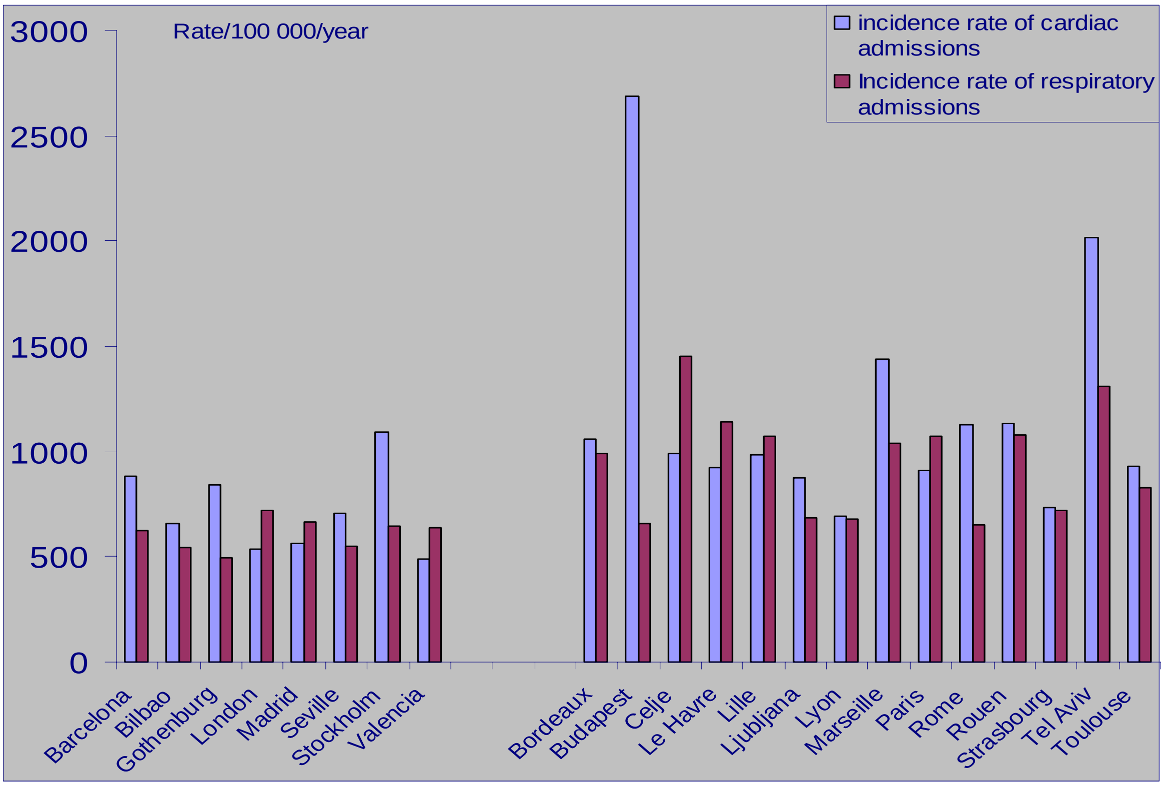
Twenty-two cities provided data on hospital admissions in Apheis-3. All the registries run a quality-control programme, and completeness in the diagnosis for the cause of admission is quite high, with a percentage of missing data of 1% or lower in 19 of the 22 registries. We didn't know this percentage in two cities (London and Tel Aviv).

The main problem for comparability remains the differences in the availability of information in the registries. The information sources used in Barcelona, Bilbao, Budapest, Gothenburg, London, Madrid, Seville, Stockholm and Valencia allowed selecting emergency admissions. Yet, for Bordeaux, Celje, Le Havre, Lille, Ljubljana, Lyon, Marseille, Paris, Rome, Rouen, Strasbourg, Tel Aviv and Toulouse, it was not possible to distinguish between emergency and total admissions.

[5] United Nations. Population Division Department of Economic and Social Affairs. World Population Prospects: The 2000 Revision.

Athens, Bucharest, Cracow and Dublin have not estimated the impact on hospital admissions.

Figure 5. Incidence rates for hospital admissions in 22 cities (9 with emergency admissions, 13 with general admissions)



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Cities with emergency admissions Cities with general admissions

In the nine cities where emergency-admissions data was available, the incidence rate for cardiac admissions for all ages was the highest in Budapest (2 686 per 100 000) followed by Stockholm (1 093 per 100 000), and the lowest was for Valencia (485 per 100 000). The incidence rate for respiratory admissions was slightly higher for London (719 per 100 000).

The high rate for cardiac emergency hospital admissions in Budapest was checked and compared to the previous 3 years. It may be explained by the high rate of mortality and also by people's habit of calling for an ambulance instead of going to general practitioners in Budapest.

In the 13 cities where the distinction between emergency and non-emergency admissions could not be made, the incidence rate for cardiac admissions for all ages was the highest for Tel Aviv (2 018 per 100 000); five cities showed rates above 1 000 per 100 000: Bordeaux, Lille, Marseille, Rome, and Rouen. Incidence rates for respiratory admissions were higher for Celje, Le Havre, Marseille, Paris, Rouen and Tel Aviv (above 1 000 per 100 000).

Note that in both groups, all other things being equal, the incidence rates for respiratory admissions all ages are 3 to 6 times lower than in Apheis-2, where only respiratory admissions over 65 years of age were included. Incidence rates for cardiac admissions are more variable and remain quite similar to Apheis-2.

The Apheis-3 HIA findings presented below consider the effects of short- and long-term exposure to particles on mortality alone. Because of the difficulties in comparability discussed in the "Interpretation of findings" section, we only show the HIA on hospital admissions city by city.

Benefits of reducing PM_{10}, black smoke and $PM_{2.5}$ levels for different scenarios

The following two tables summarise the HIAs conducted in Apheis-3 specifying: the air pollution indicators, the health outcomes and their ICD codes, the HIA tool used, the relative risks (or E-R functions) selected, the scenarios and the references.

Table 5a. Summary of data components used for health impact assessment of short-term exposure in Apheis-3.

Summary SHORT-TERM HIA							
	Health indicator	ICD		Tool	RR (95% IC) For 10 $\mu g/m^3$ increase	Scenarios	References
Attributable cases		**ICD9**	**ICD10**			**Daily mean**	
ST HIA for all Apheis cities							
Black smoke	All ages, all causes mortality (excluding external causes) All ages, cardiovascular mortality All ages, respiratory mortality All ages, cardiac hospital admissions All ages, respiratory hospital admissions	< 800 390-459 460-519 390-429 460-519	A00-R99 I00-I99 J00-J99 I00-I52 J00-J99	PSAS-9 Excel spreadsheet	1.006 (1.004 - 1.009) 1.004 (1.002 - 1.007) 1.006 (0.998 - 1.015) 1.011 (1.004 - 1.019) 1.0030 (0.9985 -1.0075)	Reduction to 50 $\mu g/m^3$ Reduction to 20 $\mu g/m^3$ Reduction by 5 $\mu g/m^3$	WHO, 2004 WHO, 2004 WHO, 2004 APHEIS 3, 2004 APHEIS 3, 2004
PM_{10} very short-term	All ages, all causes mortality (excluding external causes) All ages, cardiovascular mortality All ages, respiratory mortality All ages, cardiac hospital admissions All ages, respiratory hospital admissions	< 800 390-459 460-519 390-429 460-519	A00-R99 I00-I99 J00-J99 I00-I52 J00-J99	PSAS-9 Excel spreadsheet	1.006 (1.004 - 1.008) 1.009 (1.005 - 1.013) 1.013 (1.005 - 1.021) 1.006 (1.003 - 1.009) 1.0114 (1.0062 - 1.0167)	Reduction to 50 $\mu g/m^3$ Reduction to 20 $\mu g/m^3$ Reduction by 5 $\mu g/m^3$	WHO, 2004 WHO, 2004 WHO, 2004 APHEIS 3, 2004 APHEIS 3, 2004
PM_{10} cumulative short-term (40 days)	All ages, all causes mortality (excluding external causes) All ages, cardiovascular mortality All ages, respiratory mortality	< 800 390-459 460-519	A00-R99 I00-I99 J00-J99	PSAS-9 Excel spreadsheet	1.01227 (1.0081 - 1.0164) 1.01969 (1.0139 - 1.0255) 1.04206 (1.0109 - 1.0742)	Reduction to 50 $\mu g/m^3$ Reduction to 20 $\mu g/m^3$ Reduction by 5 $\mu g/m^3$	A. Zanobetti et al, 2002 A. Zanobetti et al, 2003 A. Zanobetti et al, 2003
Complementary ST HIA for some Apheis cities							
PM_{10} with shrunken estimates	All ages, all causes mortality (excluding external causes)	< 800	A00-R99	PSAS-9 Excel spreadsheet	RRs calculated from betas & se of Apheis shrunken estimates for each city	Reduction to 50 $\mu g/m^3$ Reduction to 20 $\mu g/m^3$ Reduction by 5 $\mu g/m^3$	Apheis 3, 2004

Table 5b. Summary of data components used for health impact assessment of long-term exposure in Apheis-3.

Summary LONG-TERM HIA							
	Health indicator	**ICD 9**	**ICD10**	**Tool**	**RR (95% IC) For 10 µg/m³ increase**	**Scenarios**	**References**
LT HIA for all-cities report							
Attributable cases						**Annual mean**	
PM_{10}	All causes mortality (excluding external causes)	< 800	A00-R99	PSAS-9 Excel spreadsheet	Trilateral & Apheis 2 1.043 (1.026 -1.061)	Reduction to 40 µg/m³ Reduction to 20 µg/m³ Reduction by 5 µg/m³	Kunzli et al. 2000
$PM_{2.5}$	All causes mortality Cardiopulmonary mortality Lung cancer	0-999 401-440 and 460-519 162	A00-Y98 I10-I70 and J00-J99 C33-C34	PSAS-9 Excel spreadsheet	Average Pope, 2002 1.06 (1.02 - 1.11) 1.09 (1.03 - 1.16) 1.14 (1.04 - 1.23)	Reduction to 20 µg/m³ Reduction to 15 µg/m³ Reduction by 3.5 µg/m³	C.A. III Pope, 2002 C.A. III Pope, 2002 C.A. III Pope, 2002
Gain in life expectancy						**Annual mean**	
$PM_{2.5}$	Age > 30 only All causes mortality Cardiopulmonary mortality Lung cancer	0-999 401-440 and 460-519 162	A00-Y98 I10-I70 and J00-J99 C33-C34	AirQ	Average Pope, 2002 1.06 (1.02 - 1.11) 1.09 (1.03 - 1.16) 1.14 (1.04 - 1.23)	Reduction to 20 µg/m³ Reduction to 15 µg/m³ Reduction by 3.5 µg/m³	C.A. III Pope, 2002 C.A. III Pope, 2002 C.A. III Pope, 2002

Exposure and outcome data for HIAs of short-term exposure

For HIAs of short-term exposure, we used PM_{10} and BS levels <u>measured directly</u> at monitoring stations (see Table 4).

We also used daily mortality means and rates shown in Table 6 and the following map.

Table 6. Daily mean, standard deviation, daily rate per 100 000 deaths for each health indicator in the 26 cities for short-term health impact assessment calculations in Apheis-3

City	Year	All causes mortality			Cardiovascular mortality			Respiratory mortality		
		Daily mean	Standard deviation	Daily rate per 100 000	Daily mean	Standard deviation	Daily rate per 100 000	Daily mean	Standard deviation	Daily rate per 100 000
Athens	2001	76.0	11.0	2.4	38.3	7.6	1.2	6.0	2.8	0.2
Barcelona	2000	38.5	8.3	2.5	13.0	6,7	0.9	5.0	2.3	0.3
Bilbao	2001	17.0	4.5	2.4	5.6	2.4	0.8	1.6	1.2	0.2
Bordeaux	1999	12.5	3.7	2.1	4.1	2.1	0.7	1.0	1.0	0.2
Bucharest	2000	57.0	n.a.	2.8	33.4	n.a.	1.7	3.0	n.a.	0.1
Budapest	2000	63.9	10.1	3.7	33.8	8.2	1.9	1.8	1.6	0.1
Celje	2000	1.5	1.2	3.1	0.7	0.8	1.4	0.2	0.4	0.4
Cracow	2000	17.0	4.9	2.3	8.7	3.2	1.2	0.7	0.9	0.1
Dublin	2000	12.3	4.1	2.5	5.1	2.4	1.0	1.8	1.7	0.4
Gothenburg	2000	12.0	3.7	2.6	5.9	2.5	1.3	0.9	1.0	0.2
Le Havre	1999	5.7	2.5	2.3	1.7	1.3	0.7	0.5	0.7	0.2
Lille	1999	23.0	5.4	2.1	7.0	2.9	0.4	2.0	1.7	0.2
Ljubljana	2000	6.9	2.8	2.6	3.0	1.9	1.1	0.5	0.7	0.2
London	2001	144.1	18.4	2.1	57.9	9.6	0.8	22.1	6.4	0.3
Lyon	1999	15.4	4.6	2.0	5.2	2.4	0.7	1.2	1.2	0.2
Madrid	2000	68.7	11.3	2.3	22.3	5.3	0.8	8.8	4.1	0.3
Marseille	1999	21.6	6.0	2.5	7.2	3.0	0.8	2.0	1.6	0.2
Paris	1999	114.0	16.7	1.9	32.9	6.9	0.5	9.0	4.1	0.2
Rome	2001	56.5	9.5	2.1	23.2	5.7	0.9	3.1	1.9	0.1
Rouen	1999	9.1	3.2	2.1	2.9	1.9	0.7	0.7	0.9	0.2
Seville	2000	15.4	4.6	2.2	6.7	2.8	1.0	1.5	1.5	0.2
Stockholm	2000	28.3	6.4	2.4	13.5	4.1	1.2	2.3	1.7	0.2
Strasbourg	1999	8.6	3.0	2.0	3.0	1.6	0.7	0.8	0.8	0.2
Tel Aviv	1998	24.4	n.a.	2.2	9.9	n.a.	0.9	1.8	n.a.	0.2
Toulouse	1999	11.7	3.9	1.7	3.8	2.0	0.6	0.9	1.0	0.1
Valencia	2000	15.8	4.7	2.1	5.7	2.5	0.8	1.8	1.6	0.2

n.a.: not available

Map of daily rates per 100 000 deaths for each health indicator in the 26 cities for short-term health impact assessment calculations in Apheis-3

Exposure and outcome data for HIAs of long-term exposure

As described in the "Methods" section above, for long-term HIAs, because the exposure-response functions used are taken from publications that used gravimetric methods (Künzli et al. 2000 and Pope et al. 2002), for consistency we corrected the automatic PM_{10} measurements used by most of the cities by a specific correction factor in order to compensate for losses of volatile particulate matter. A local correction factor chosen with the advice of the local air-pollution network was used when available; otherwise cities used the 1.3 European default correction factor recommended by the EC working group on particulate matter.

It should be remembered that, for most of the cities, $PM_{2.5}$ measurements were not available and that the cities had to calculate $PM_{2.5}$ data from PM_{10} measurements. For this purpose a conversion factor was used: a local conversion factor (ranging between 0.5 and 0.8) with the advice of the local air- monitoring network or 0.7 as the default European conversion factor, because no local factor was available. The default factor of 0.7 was recommended by the Apheis Exposure Assessment Working Group (see "Methods" section and Appendix 3).
The following table provides the corrected/converted PM levels used for long-term HIAs.

Table 7. Corrected PM_{10} and converted $PM_{2.5}$ levels (µg/m^3) in 26 cities for long-term health impact assessment calculations in Apheis-3

City	Year	corrected PM_{10}*				converted $PM_{2.5}$ **			
		Mean	SD[1]	P5[2]	P95[3]	Mean	SD	P5	P95
Athens	2001	68	25	32	113	31	14	14	56
Bilbao	2002	43	20	19	83	30	14	13	58
Bordeaux	2000/2002[4]	24	14	10	56	16	9	7	37
Bucharest[5]	2000					43	14	28	62
Budapest[5]	2000	38	16	17	65	27	11	12	45
Celje	2000	47	26	14	91	33	18	10	64
Cracow	2000	40	22	15	87	32	18	12	70
Gothenburg	2000	18	10	6	36	12	6	4	23
Le Havre	2000	23	10	12	42	16	7	8	29
Lille	2001	26	15	12	48	17	10	8	32
Ljubljana	2000	41	31	5	94	29	22	4	65
London	2001	29	11	16	50	20	8	11	35
Lyon	2000	25	14	11	49	17	10	7	34
Madrid	2000	37	17	15	69	19	9	8	35
Marseille	2000/2002[4]	28	10	14	46	18	7	9	30
Paris	2000	26	13	13	47	18	9	9	33
Rome	2001	61	22	32	100	43	15	23	70
Rouen	2002	24	11	12	45	17	8	9	32
Seville	2000	50	13	31	73	35	9	22	51
Stockholm	2000	17	9	7	34	11	6	5	22
Strasbourg	2002	25	14	11	50	18	10	8	35
Tel Aviv	1998	85	155	38	136	42	78	19	68
Toulouse	2000	26	12	12	49	17	8	8	32

* PM_{10} measurements corrected by European or local correction factor

* $PM_{2.5}$ measurements converted from PM_{10} by European or local conversion factor

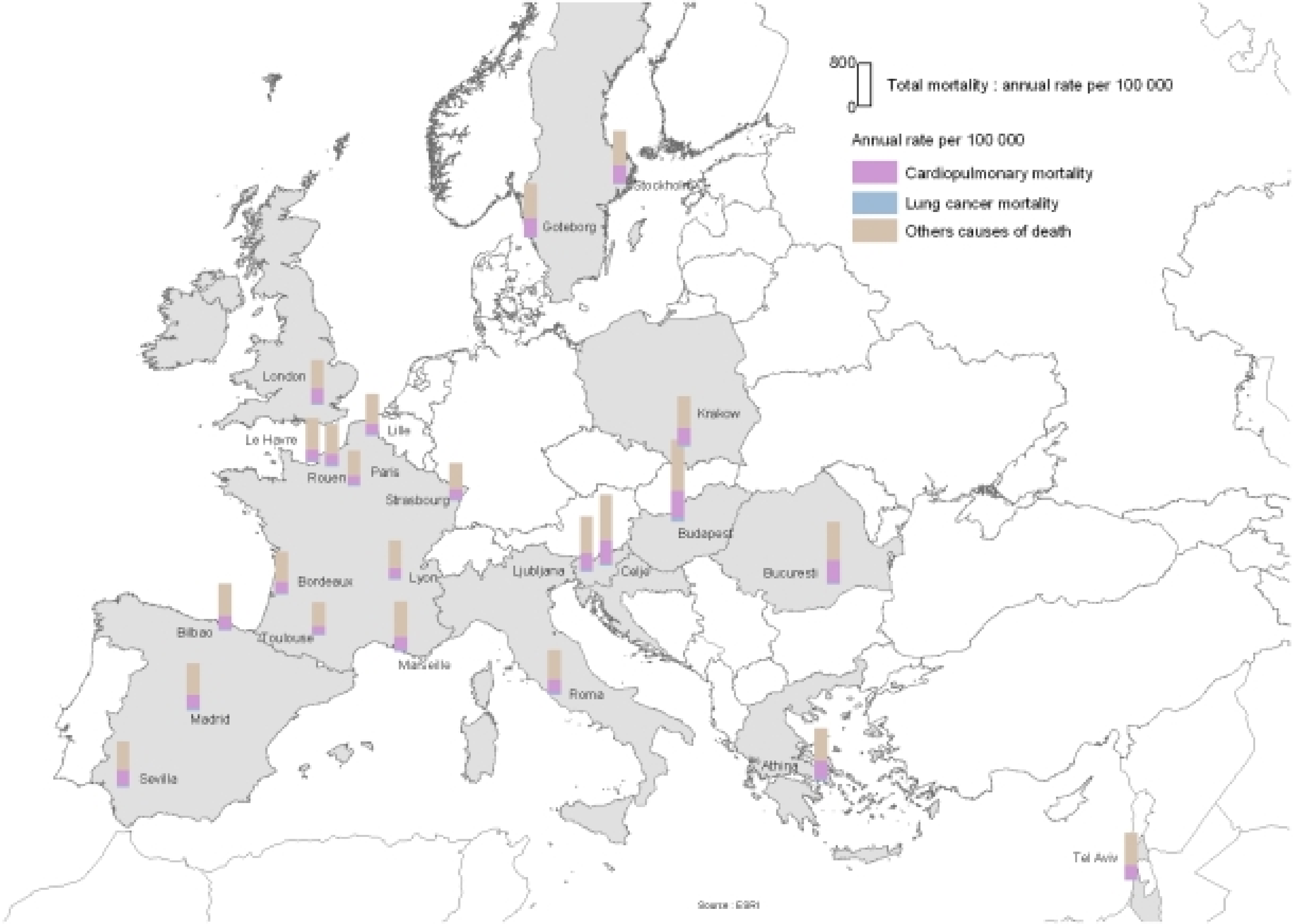
1. SD: Standard deviation
2. P5: 5th percentile of the distribution of the pollutant
3. P95: 95th percentile of the distribution of the pollutant
4. For Bordeaux, year 2000 for PM_{10} and 2002 for $PM_{2.5}$; for Marseille, 2000 for PM_{10} and 2002 for $PM_{2.5}$
5. PM_{10} converted from TSP

For HIAs of long-term exposure, we used the annual deaths and rates shown in Table 8 and the corresponding map.

Table 8. Annual deaths and rates per 100 000 deaths for each health indicator in the 26 cities for long-term health impact assessment calculations in Apheis-3

City	Year	Total mortality		Cardiopulmonary mortality		Lung cancer mortality	
		Annual deaths	Annual rate per 100 000	Annual deaths	Annual rate per 100 000	Annual deaths	Annual rate per 100 000
Athens	2001	29072	912	15931	500	1583	50
Bilbao	2001	6440	909	2505	354	369	52
Bordeaux	1999	4928	844	1716	294	256	44
Bucharest	2000	21831	1086	12216	608	1005	50
Budapest	2000	24951	1434	13049	750	1584	91
Celje	2000	617	1261	310	633	32	65
Cracow	2000	6572	891	3354	455	392	53
Gothenburg	2000	4550	974	2378	509	157	34
Le Havre	1999	2258	889	762	300	112	44
Lille	1999	8977	822	3182	292	500	46
Ljubljana	2000	2692	1022	1203	457	143	54
London	2001	53947	794	27233	401	3137	46
Lyon	1999	6055	774	2199	281	337	43
Madrid	2000	26061	887	10787	367	1426	49
Marseille	1999	8486	991	3109	363	441	52
Paris	1999	44257	718	14273	232	2379	39
Rome	2001	21737	822	9230	349	1708	65
Rouen	1999	3621	833	1235	284	206	47
Seville	2000	5646	806	2898	414	308	44
Stockholm	2000	11307	964	5763	491	402	34
Strasbourg	1999	3319	736	1254	278	198	44
Tel Aviv	1998	10032	912	4125	375	308	28
Toulouse	1999	4552	657	1574	226	232	33

Map of annual rates per 100 000 deaths for each health indicator in the 26 cities for long-term health impact assessment calculations in Apheis-3



Summary findings of Apheis-3 HIAs in terms of potential reductions in the number of "premature" deaths

The following table summarises the HIA findings in terms of number of "premature" deaths and rates per 100 000 that, all other things being equal, could be potentially reduced for different scenarios of particulate pollution reductions. All these findings are detailed in the following pages.

Table 9. Summary findings of Apheis-3 HIAs in terms of potential reductions in the number of "premature" deaths and rates per 100 000

Summary findings in terms of attributable cases								
Air pollution indicator	Health indicator	HIA scenario	Potential reduction in the number of deaths					
			Very short-term		Cumulative short-term		Long-term	
			Number of deaths	Number of deaths/ 100 000/ year	Number of deaths	Number of deaths/ 100 000/ year	Number of deaths	Number of deaths/ 100 000/ year
BS	All causes mortality*	Reduction to 50 µg/m^3	572	2				
		Reduction to 20 µg/m^3	1296	5				
		Reduction by 5 µg/m^3	557	2				
	Cardiovascular mortality	Reduction to 50 µg/m^3	188	1				
		Reduction to 20 µg/m^3	405	2				
		Reduction by 5 µg/m^3	142	1				
	Respiratory mortality	Reduction to 50 µg/m^3	47	0.2				
		Reduction to 20 µg/m^3	109	0.4				
		Reduction by 5 µg/m^3	61	0.2				
PM_{10}	All causes mortality*	Reduction to 50 ** µg/m^3 /40** µg/m^3	559	2	1150	3	8550	24
		Reduction to 20 µg/m^3	2580	7	5240	15	21385	60
		Reduction by 5 µg/m^3	868	2	1739	5	6143	17
	Cardiovascular mortality	Reduction to 50 µg/m^3	412	1	877	2		
		Reduction to 20 µg/m^3	1741	5	3458	10		
		Reduction by 5 µg/m^3	527	1	897	2		
	Respiratory mortality	Reduction to 50 µg/m^3	87	0.2	288	1		
		Reduction to 20 µg/m^3	429	1	1348	4		
		Reduction by 5 µg/m^3	162	0.5	489	1		
$PM_{2.5}$	All causes mortality	Reduction to 20 µg/m^3					11375	32
		Reduction to 15 µg/m^3					16926	47
		Reduction by 3.5 µg/m^3					6355	18
	Cardiopulmonary mortality	Reduction to 20 µg/m^3					8053	22
		Reduction to 15 µg/m^3					11612	32
		Reduction by 3.5 µg/m^3					4199	12
	Lung cancer mortality	Reduction to 20 µg/m^3					1296	4
		Reduction to 15 µg/m^3					1901	5
		Reduction by 3.5 µg/m^3					743	2

* Excluding external causes.
** Reduction to 50 µg/m^3 for very short-term and cumulative short-term. Reduction to 40 µg/m^3 for long-term.

NOTE: IT IS OF CRUCIAL IMPORTANCE TO NOTE THAT the HIA findings shown in the table above are for different scenarios and for different particulate indicators. THEY MUST NOT BE ADDED TOGETHER because the pollutants are highly correlated and some of the impacts provided by one air-pollution indicator are already included in another indicator and some of the impacts provided in one scenario are already included in another scenario.

Black smoke findings

We considered only the short-term exposure or acute-effects scenarios, since no reliable exposure-response functions were available for the long-term effects of black smoke at the time we did the analysis.

As we did for Apheis-2, we considered the application of PM_{10} scenarios to BS beneficial, even if the objective is not to compare PM_{10} and BS findings.

In Apheis-3, in addition to total mortality excluding external causes, we also conducted HIAs for cardiovascular and respiratory mortality.

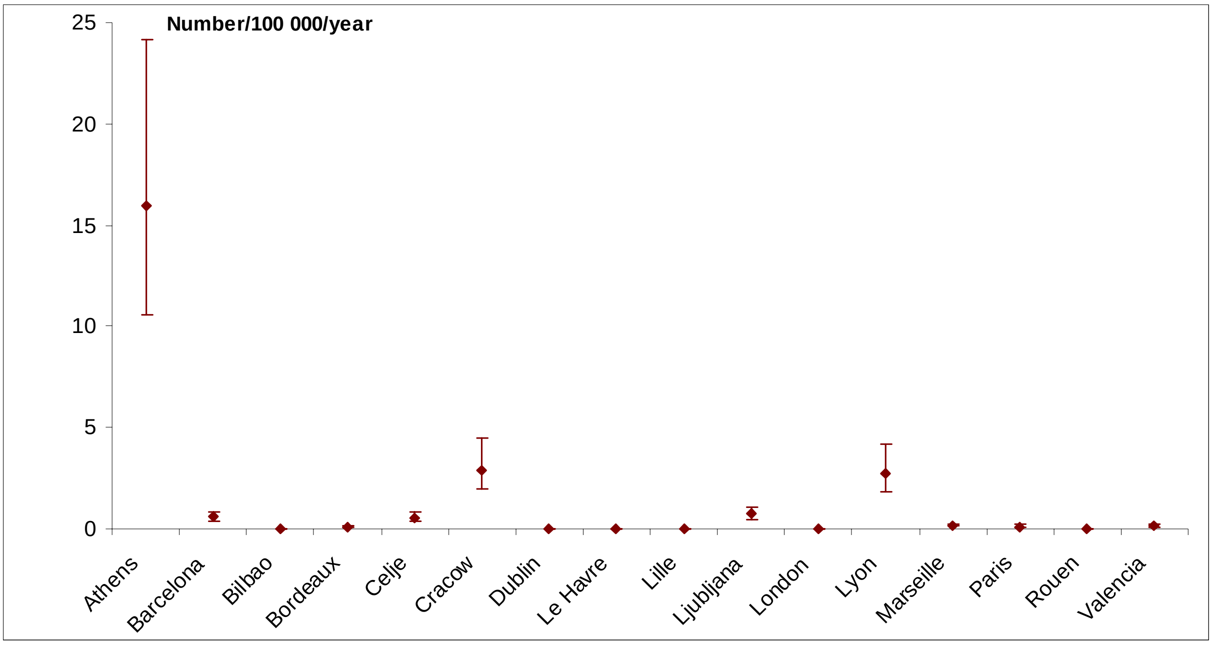
Acute effects scenarios

We used three scenarios to estimate the acute effects of short-term exposure to BS on mortality over a 1-year period:

- reduction of BS levels to a 24-hour value of 50 $\mu g/m^3$ on all days exceeding this value
- reduction of BS levels to a 24-hour value of 20 $\mu g/m^3$ on all days exceeding this value
- reduction by 5 $\mu g/m^3$ of all the 24-hour daily values of BS.

1. Black smoke: Short-term impact on total mortality (ICD9 < 800)

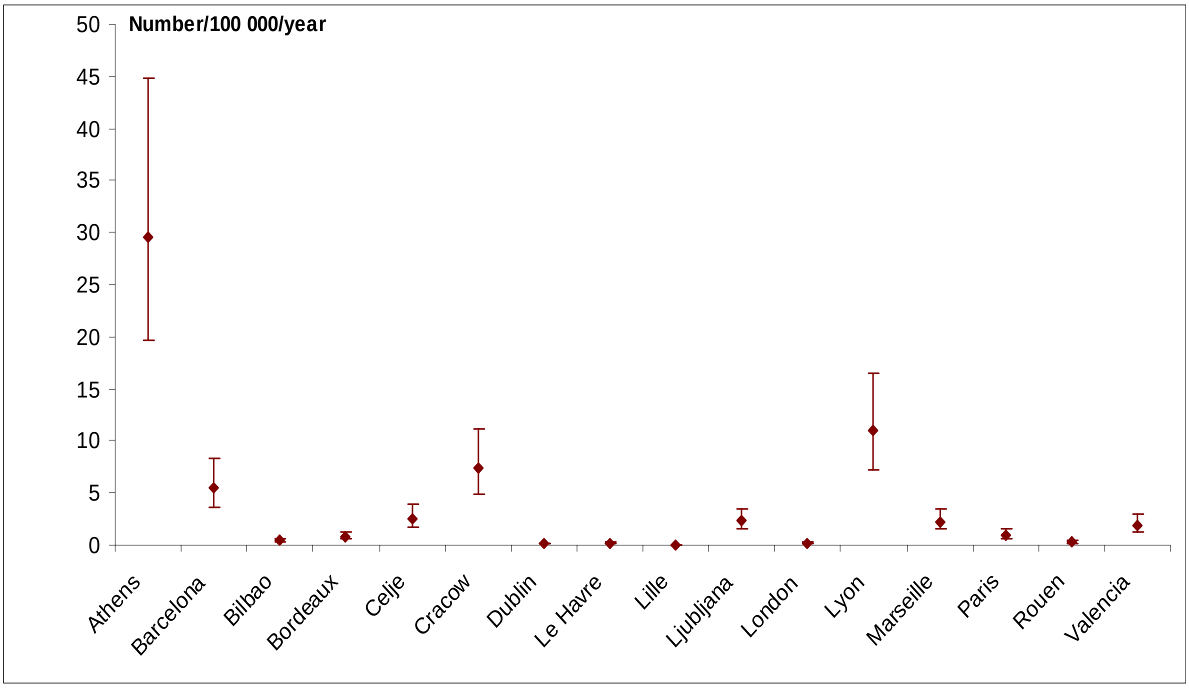
Figure 6. Black smoke: Short term (ST) impact on all-causes mortality (ICD 9 < 800). Reductions to 50 µg/m³. Number of "premature" deaths per 100 000 inhabitants



Among the 16 cities that measured black smoke, all other things being equal, Athens would show by far the highest decrease in the number of "premature" deaths per 100 000 inhabitants (16 deaths) if BS levels for all days exceeding a 24-hour value of 50 µg/m³ were reduced to 50 µg/m³. Remember that Athens shows the highest BS levels, probably because of the direct influence of traffic. Cracow and Lyon follow with almost three "premature" deaths per 100 000. The health benefits of this scenario for the other cities are extremely low. The 16 cities measuring BS would average two "premature" deaths per 100 000 inhabitants.

In these 16 cities, totalling 24 663 565 inhabitants, our HIA found that, all other things being equal, 572 "premature" deaths could be prevented if short-term exposure to outdoor concentrations of BS were reduced to 50 µg/m³.

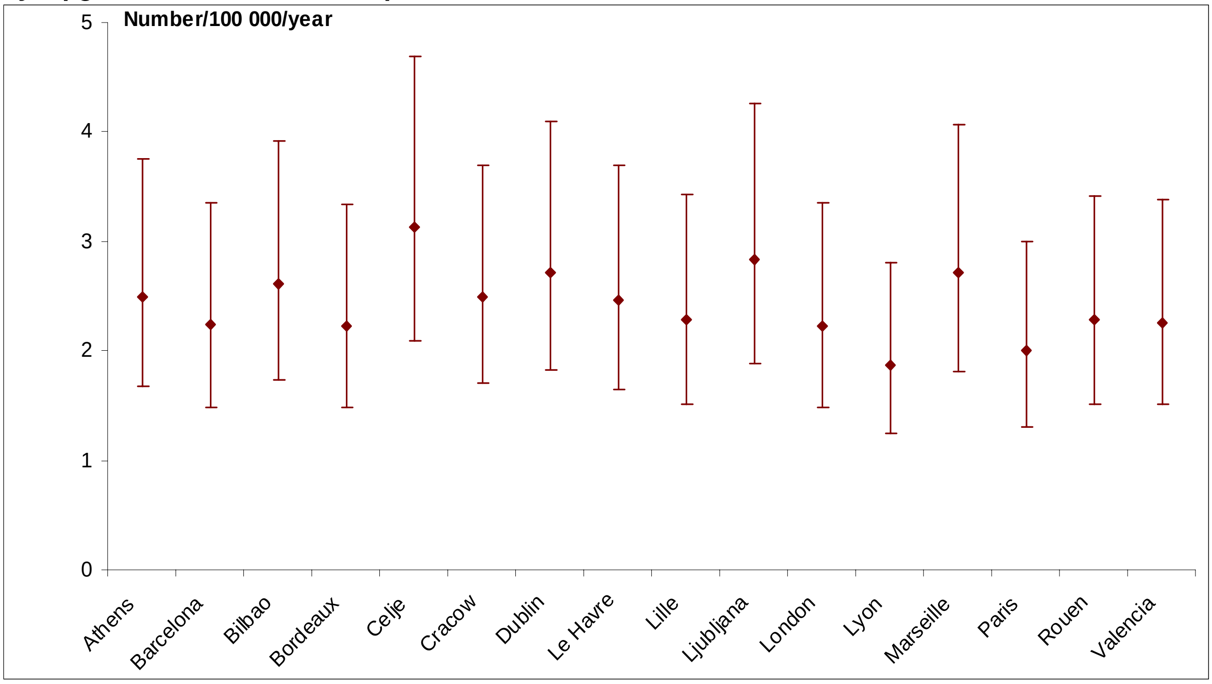
Figure 7. Black smoke: Short term (ST) impact on all-causes mortality (ICD9 < 800**). Reductions to 20 µg/m³. Number of deaths per 100 000 inhabitants**



If BS levels for all days when they exceeded a 24-hour value of 20 µg/m³ were reduced to 20 µg/m³ in the 16 cities measuring BS, all other things being equal, Athens would continue to show the highest decrease in the number of «premature» deaths per 100 000 inhabitants (30 "premature" deaths). Lyon would follow with 11 deaths, Cracow with 7 and Barcelona with 5 deaths per 100 000. Together, the 16 cities measuring BS would average five «premature» deaths per 100 000 inhabitants.

In these 16 cities, our HIA found that, all other things being equal, 1 296 "premature" deaths could be prevented if short-term exposure to outdoor concentrations of BS were reduced to 20 µg/m³.

Figure 8. Black smoke: Short term (ST) impact on all-causes mortality (ICD9 < 800). Reductions by 5 µg/m³. Number of deaths per 100 000 inhabitants



If daily BS levels were reduced by 5 µg/m³, all other things being equal, the consequent reduction in the number of "premature" deaths per 100 000 inhabitants would range between two and three "premature" deaths per 100 000 inhabitants in the 16 cities measuring BS.

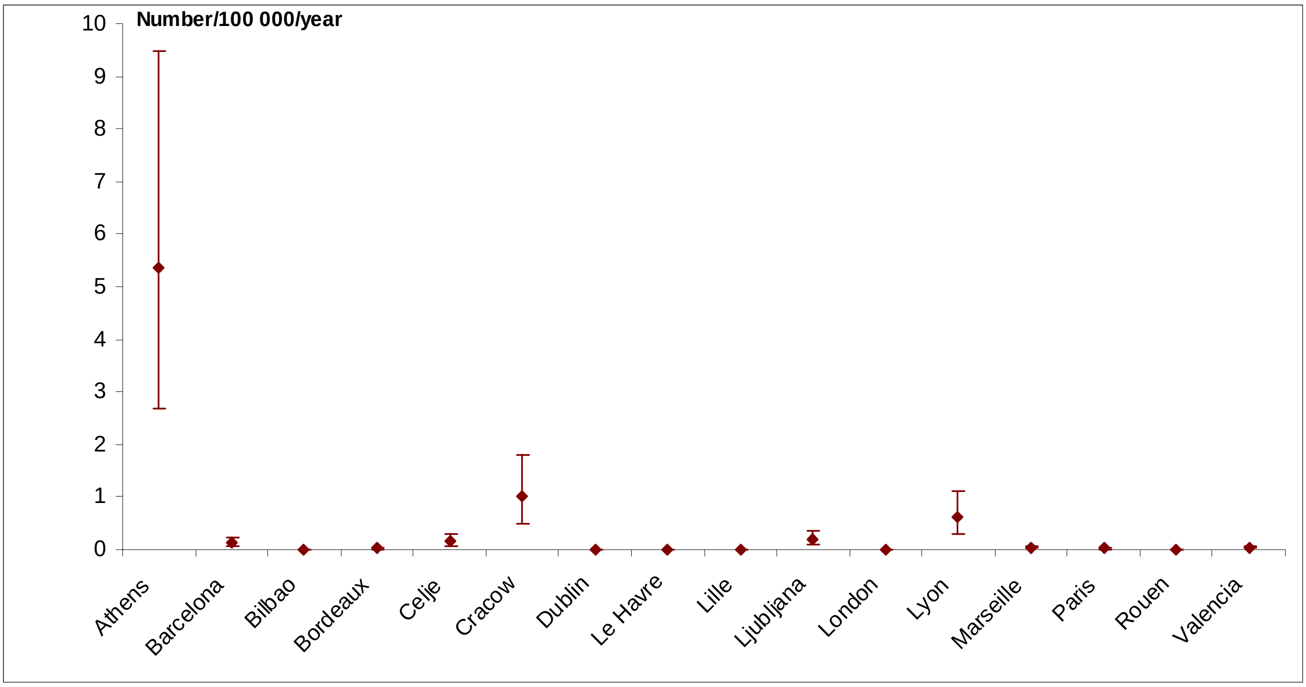
In these 16 cities, our HIA found that, all other things being equal, 557 "premature" deaths could be prevented if short-term exposure to outdoor concentrations of BS were reduced by 5 µg/m³.

All other things being equal, BS findings are quite similar to those obtained in Apheis-2.

2. Black smoke: Short-term impact on cardiovascular mortality (ICD9 390-459)

In Apheis-3, we were able to perform an HIA on BS and cause-specific mortality using newly developed E-R functions.

Figure 9. Black smoke: Short term (ST) impact on cardiovascular mortality (ICD9 390-459**). Reductions to 50 µg/m^3. Number of deaths per 100,000 inhabitants**



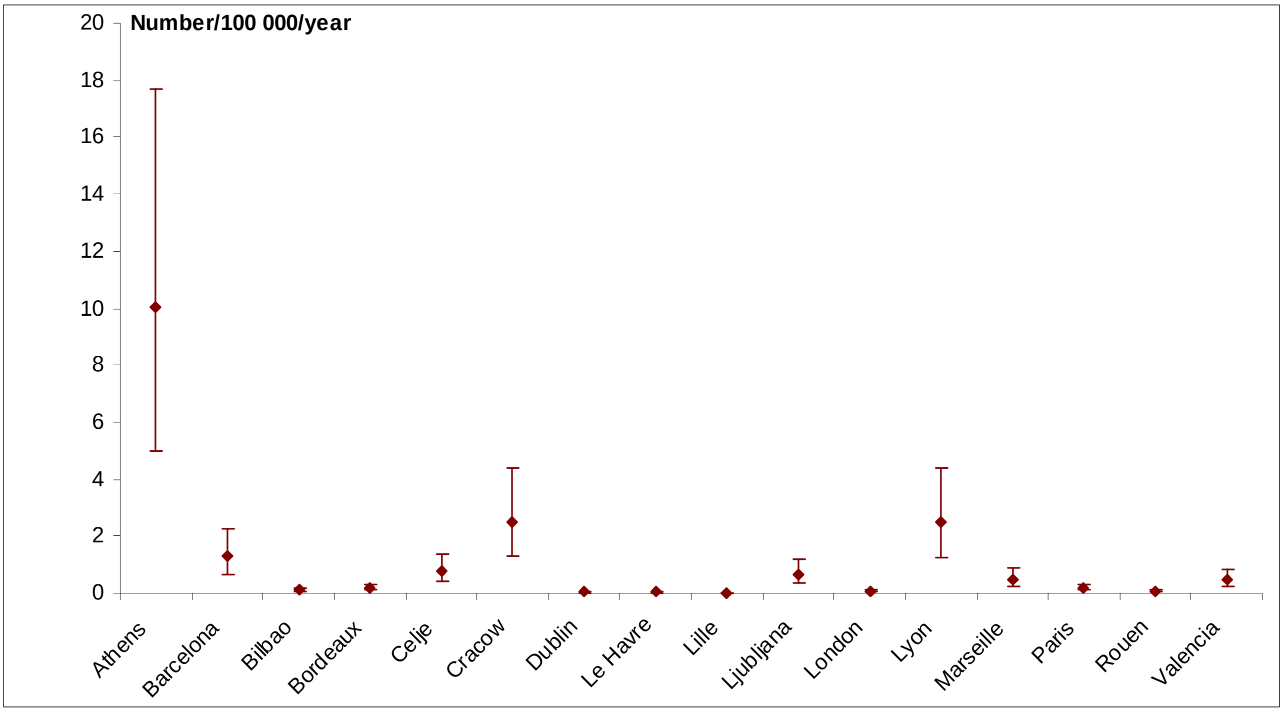
Athens continues to show the highest decrease in the number of "premature" cardiovascular deaths per 100 000 inhabitants (5 deaths) if BS levels for all days exceeding a 24-hour value of 50 µg/m^3 were reduced to 50 µg/m^3.

Cracow and Lyon follow respectively with 1 and 0.6 "premature" cardiovascular deaths per 100 000.

The health benefits of this scenario in the other cities are extremely low.

In the 16 cities that measured BS, our HIA found that, all other things being equal, 188 "premature" cardiovascular deaths could be prevented if short-term exposure to outdoor concentrations of BS were reduced to 50 µg/m^3.

Figure 10. Black smoke: Short term (ST) health impact on cardiovascular mortality (ICD9 390-459). Reductions to 20 µg/m^3. Number of deaths per 100 000 inhabitants



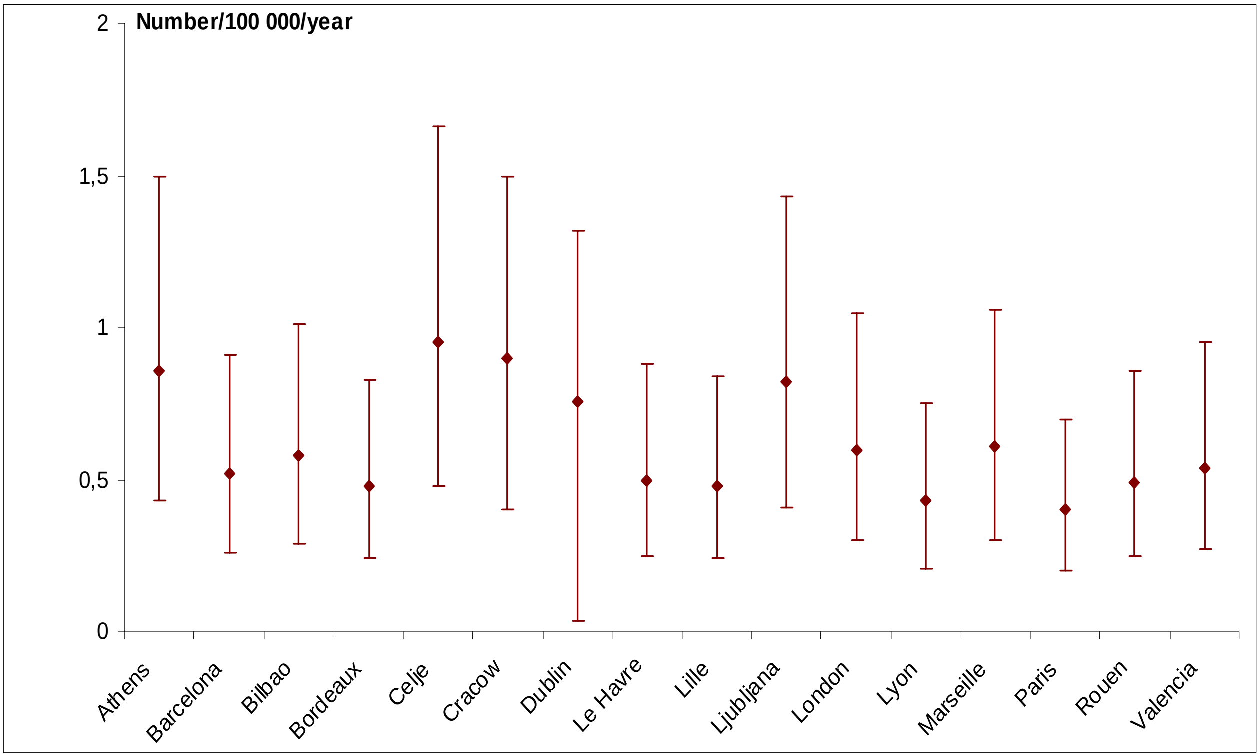
If BS levels for all days when they exceeded a 24-hour value of 20 µg/m^3 were reduced to 20 µg/m^3 in the 16 cities that measured BS, all other things being equal, Athens would show a decrease of 10 cardiovascular deaths per 100 000 inhabitants.

Lyon and Cracow would follow with 2.5 "premature" cardiovascular deaths per 100 000.

The health benefits of this scenario in the other cities are extremely low.

In the 16 cities, our HIA found that, all other things being equal, 405 "premature" cardiovascular deaths could be prevented if short-term exposure to outdoor concentrations of BS were reduced to 20 µg/m^3.

Figure 11. Black smoke: Short term (ST) health impact on cardiovascular mortality (ICD9 390-459). Reductions by 5 µg/m³. Number of deaths per 100 000 inhabitants

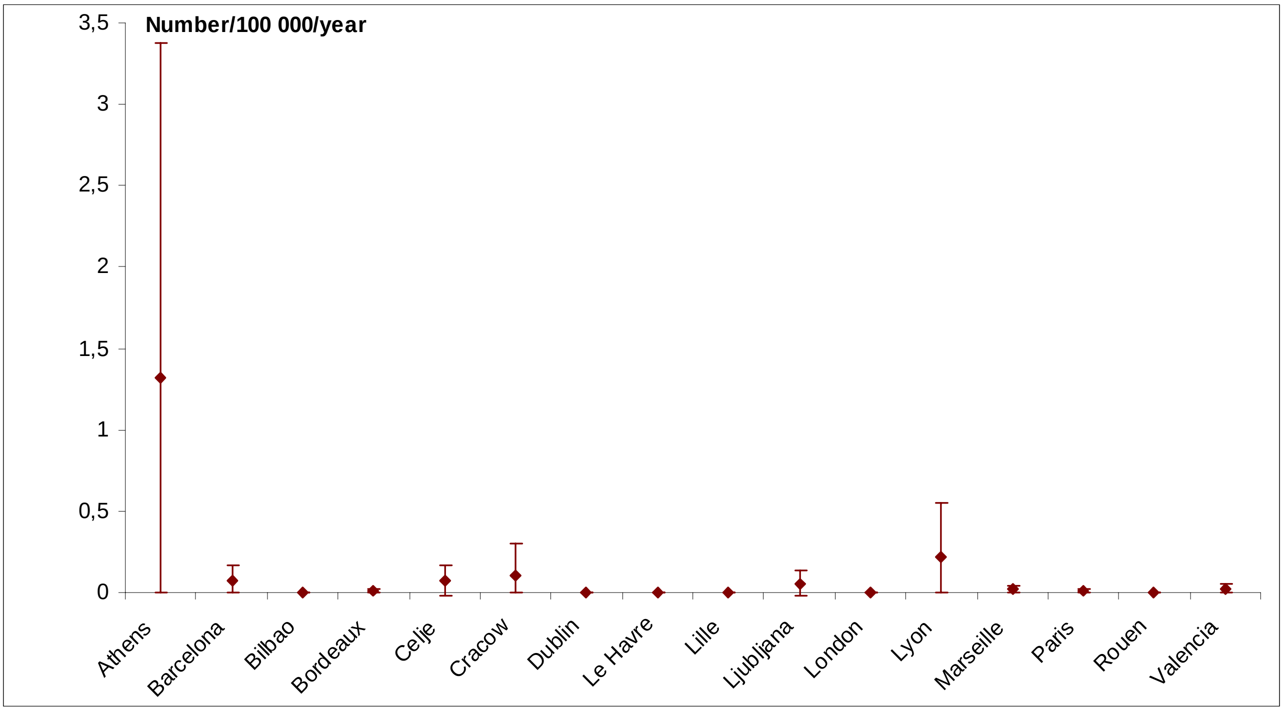


If daily BS levels were reduced by 5 µg/m³ in the 16 cities that measured BS, all other things being equal, the consequent reduction in the number of "premature" cardiovascular deaths per 100 000 inhabitants would range between 0.9 in Celje and Cracow and 0.4 in Lyon and Paris.

In the 16 cities, our HIA found that, all other things being equal, 142 "premature" cardiovascular deaths could be prevented if short-term exposure to outdoor concentrations of BS were reduced by 5 µg/m³.

3. Black smoke: Short-term impact on respiratory mortality (ICD9 390-459)

Figure 12. Black smoke: Short term (ST) health impact on respiratory mortality (ICD9 460-519). Reductions to 50 µg/m³. Number of deaths per 100 000 inhabitants

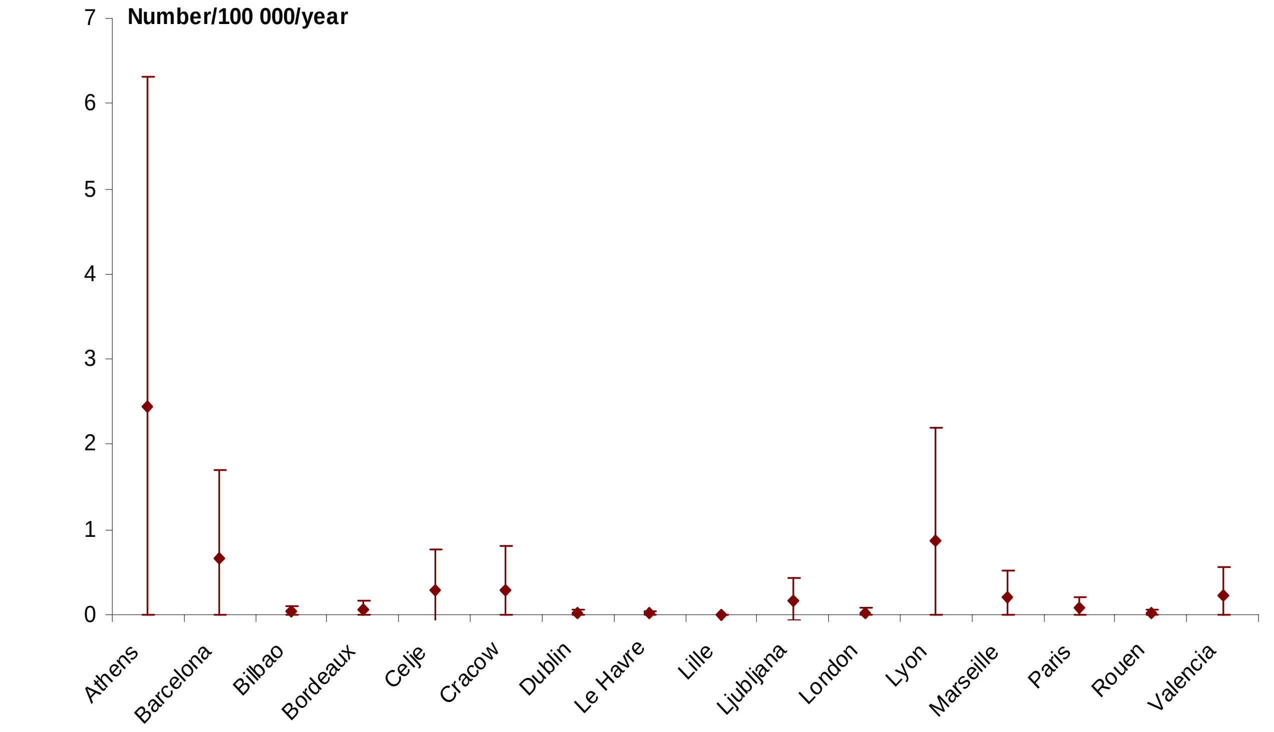


All other things being equal, Athens would show more than one "premature" respiratory deaths per 100 000 inhabitants if BS levels for all days exceeding a 24-hour value of 50 µg/m³ were reduced to 50 µg/m³.

The health benefits of this scenario for the other cities are extremely low.

In the 16 cities that measured BS our HIA found that, all other things being equal, 47 "premature" respiratory deaths could be prevented if short-term exposure to outdoor concentrations of BS were reduced to 50 µg/m³.

Figure 13. Black smoke: Short term (ST) health impact on respiratory mortality (ICD9 460-519). Reductions to 20 µg/m^3. Number of deaths per 100 000 inhabitants

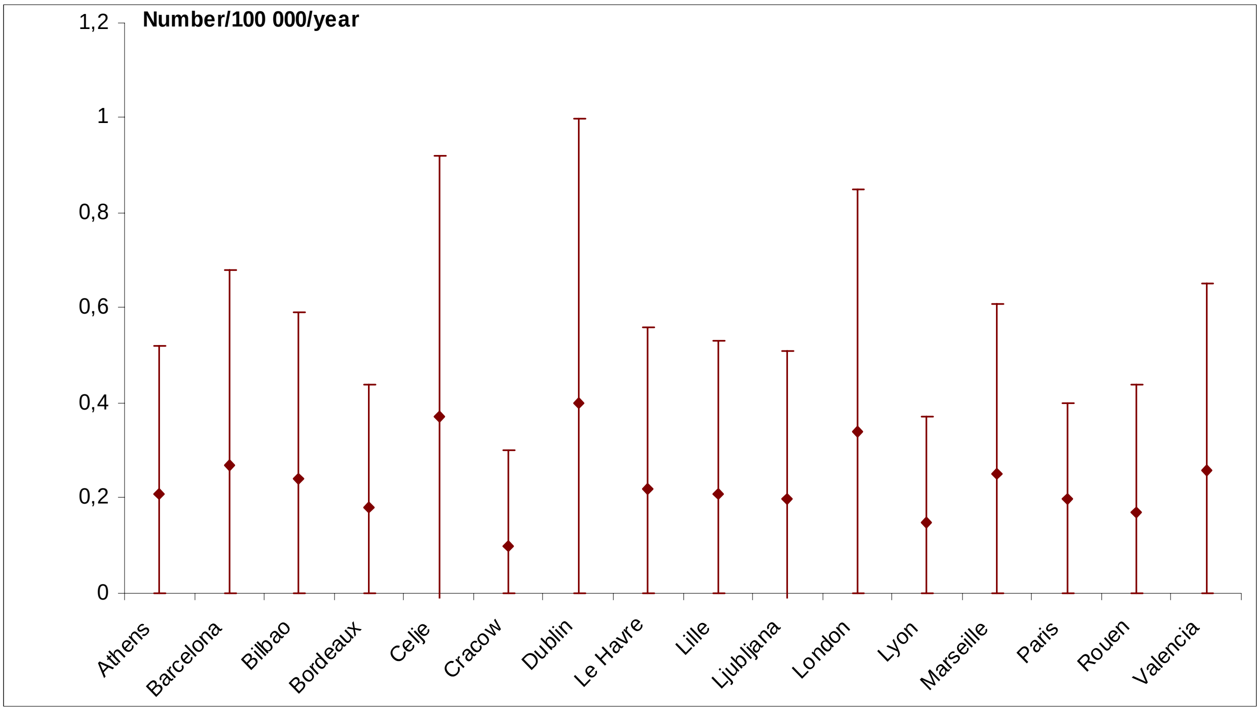


If BS levels for all days when they exceeded a 24-hour value of 20 µg/m^3 were reduced to 20 µg/m^3, all other things being equal, Athens would show a decrease of more than two respiratory deaths per 100 000 inhabitants.

The rest of the cities would show decreases below one respiratory death.

In the 16 cities measuring BS, our HIA found that, all other things being equal, 109 "premature" respiratory deaths could be prevented if short-term exposure to outdoor concentrations of BS were reduced to 20 µg/m^3.

Figure 14. Black smoke: Short term (ST) health impact on respiratory mortality (ICD9 460-519). Reductions by 5 µg/m^3. Number of deaths per 100 000 inhabitants



If daily BS levels were reduced by 5 µg/m^3 in the 16 cities measuring BS, all other things being equal, the consequent reduction in the number of «premature» respiratory deaths per 100 000 inhabitants would all be below one respiratory death.

Our HIA found that, all other things being equal, 61 "premature" respiratory deaths could be prevented if short-term exposure to outdoor concentrations of BS were reduced by 5 µg/m^3.

For each city measuring BS, the following map shows the short-term health impact for up to 2 days on total, cardiovascular and respiratory mortality for a reduction to 20 µg/m^3 in black smoke levels expressed in number of deaths per 100,000 inhabitants

Map of short-term impact (up to-2 days) on total, cardiovascular and respiratory mortality for a reduction to 20 µg/m^3 in black smoke levels. Number of deaths per 100 000 inhabitants

PM_{10} findings

In accordance with Council Directive 1999/30/EC of 22 April 1999 relating to limit values for sulphur dioxide, nitrogen dioxide and all nitrogen oxides, particulate matter and lead in ambient air (Official Journal L 163, 29/06/1999 P. 0041 – 0060) (Appendix 10), and to take account of the fact that some countries already present low levels of PM_{10}, we conducted our HIA for almost the same scenarios to reduce PM_{10} levels as used in Apheis-2.

Acute effects scenarios

We used three scenarios to estimate the acute effects of short-term exposure to raw PM_{10} values on total mortality (excluding external causes), and on , cardiovascular and respiratory mortality over a 1-year period:

- reduction of PM_{10} levels to a 24-hour value of 50 µg/m^3 (2005 and 2010 limit values for PM_{10}) on all days exceeding this value
- reduction of PM_{10} levels to a 24-hour value of 20 µg/m^3 (to allow for cities with low levels of PM_{10}) on all days exceeding this value
- reduction by 5 µg/m^3 of all the 24-hour daily values of PM_{10} (to allow for cities with low levels of PM_{10}).

Chronic effects scenarios

We used three scenarios to estimate the chronic effects of long-term exposure to corrected PM_{10} on mortality over a 1-year period:

- reduction of the annual mean value of PM_{10} to a level of 40 µg/m^3 (2005 limit values for PM_{10})
- reduction of the annual mean value of PM_{10} to a level of 20 µg/m^3 (2010 limit values for PM_{10})
- reduction by 5 µg/m^3 of the annual mean value of PM_{10} (to allow for cities with low levels of PM_{10}).

The case of Bucharest

In order to allow comparisons with the HIA findings in the other Apheis cities, we had to replace the values of PM_{10} that were missing in Bucharest (the measurements were available only four weekdays from Monday to Thursday).

1. PM_{10}: Short-term, cumulative short-term and long-term impact on total mortality (ICD9 < 800)

Because the PM_{10} 24-hour value to be reached in 2005 and 2010 is 50 µg/m³ and the annual mean to be reached in 2005 is 40 µg/m³, we have used two figures to present the short-term and long-term impacts respectively.

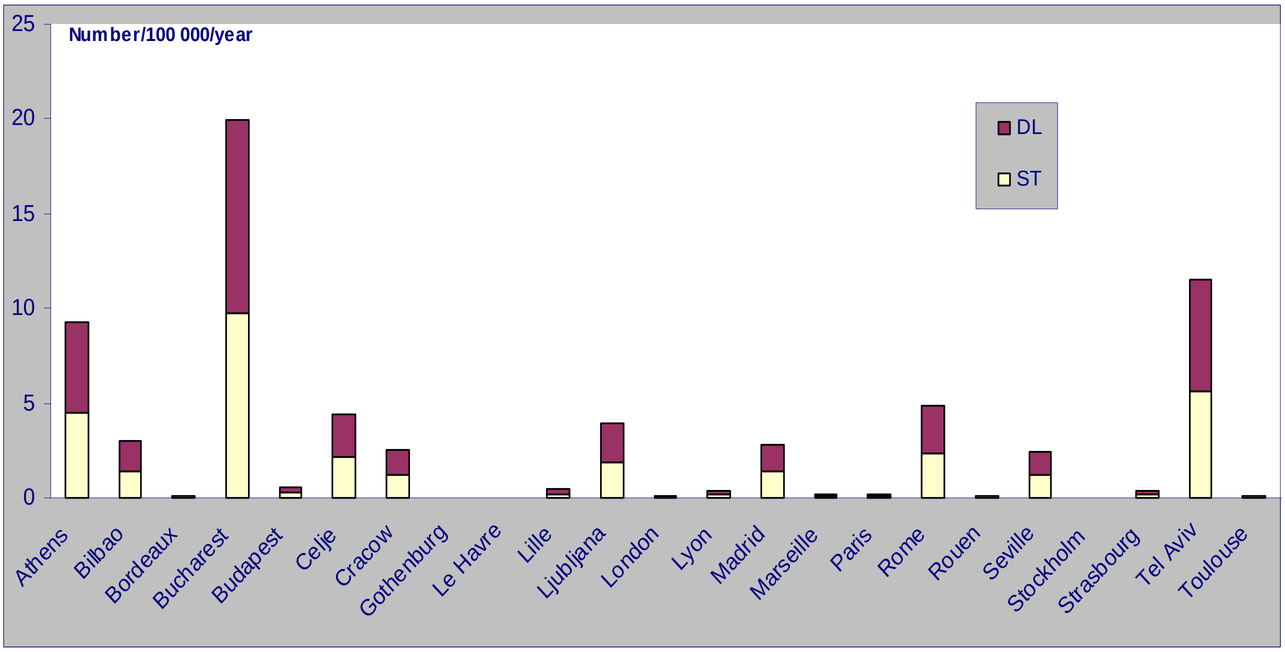
Note that in the following figures, when presenting short-term (ST) and cumulative short-term (DL) impacts in a bar, the dark part of the bar is DL-ST. Also when presenting short-term (ST), cumulative short-term (DL) and long-term impacts (LT) in a bar, one on top of the other, DL includes ST, and LT includes ST and DL.

Figure 15a shows the potential benefits, for the short-term and cumulative short-term exposures, of reducing raw PM_{10} levels to a 24-hour value of 50 µg/m³ (2005 and 2010 limit values) on all days exceeding this value. Figure 15b shows the potential benefit of reducing long-term exposure to corrected PM_{10} levels to an annual mean value of 40 µg/m³ (2005 limit values for PM_{10}).

The potential health benefits are expressed as mortality rates per 100 000 inhabitants.

Please note that the bars are slightly shifted to the right. The cities of Gothenburg, Le Havre and Stockholm have no bars because they already show 24-hour values of PM_{10} below 50 µg/m³, and do not show any health benefit in this scenario.

Figure 15a. PM_{10}: Short term (ST) and cumulative short-term (DL) health impact on all causes mortality (ICD 9 < 800). Reductions to 50 (ST-DL). Number of deaths per 100 000 inhabitants.

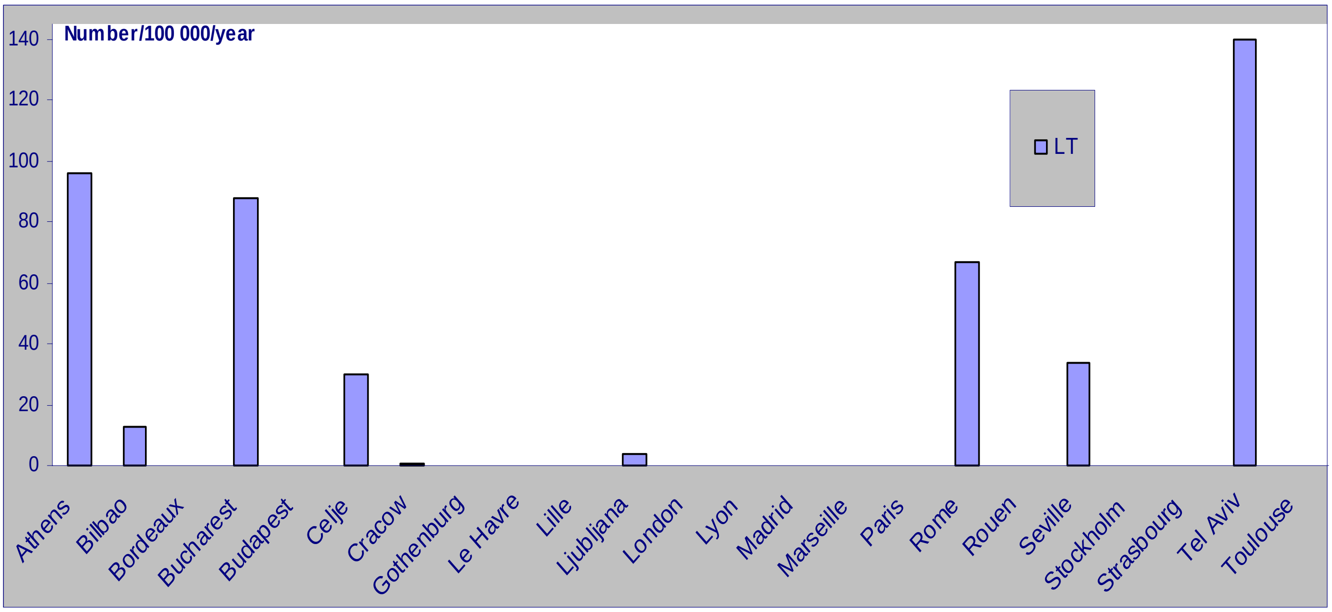


All other things being equal, if raw PM_{10} levels for all days when they exceeded this value were reduced to 50 µg/m³, the greatest benefits would be for Athens, Bucharest and Tel Aviv.

Cumulative short-term impacts would be reduced respectively by 9 «premature» deaths per 100 000 inhabitants in Athens, 20 Bucharest, and 11.5 in Tel Aviv.

For total non-violent mortality, findings of our HIA were similar to those of Apheis-2. For all the 23 cities that measured PM_{10}, the HIA estimated that, all other things being equal, 559 and 1 150 "premature" deaths related respectively to short and cumulative short-term exposure would be prevented by reducing daily raw PM_{10} to below 50 µg/m^3.

Figure 15b. PM_{10}: Long-term (LT) health impact on all causes mortality (ICD 9 < 800). Reductions to 40 (LT) µg/m^3. Number of deaths per 100 000 inhabitants.

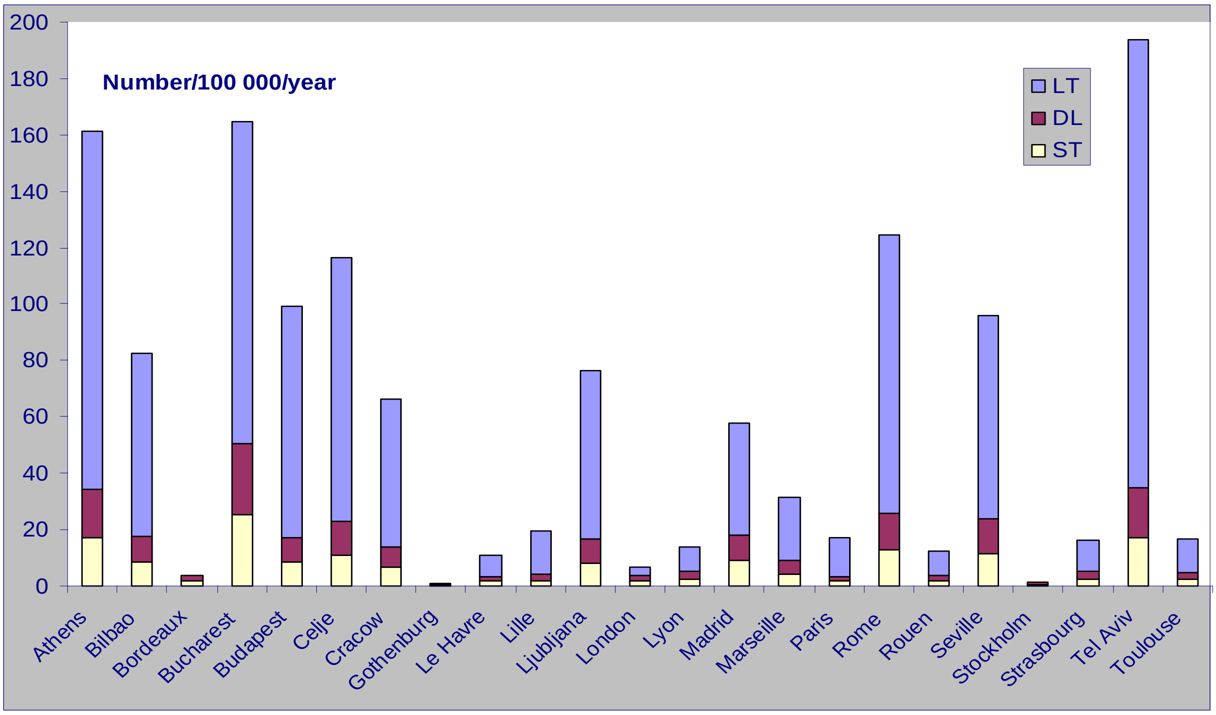


In the long term, corrected annual mean levels of PM_{10} were above 40 µg/m^3 in nine cities: Athens, Bilbao, Bucharest, Celje, Cracow, Ljubljana, Rome, Seville and Tel Aviv. All other things being equal, the reduction of the annual mean value to 40 µg/m^3 would reduce the number of "premature" deaths per 100 000 inhabitants by 96 in Athens, 88 in Bucharest, 30 in Celje, 0.5 in Cracow, 3.7 in Ljubljana, 67 in Rome, 33.7 in Seville and 139.6 in Tel Aviv. The 23 cities that measured PM_{10} would average 24 "premature" deaths per 100 000 inhabitants.

In all these 23 cities, the HIA estimated that, all other things being equal, 8 550 "premature" deaths could be prevented annually if long-term exposure to outdoor concentrations of PM_{10} were reduced to 40 µg/m^3 in each city.

Findings of our HIA of long-term exposure to PM_{10} are not comparable to Apheis-2, because in Apheis-2 we used raw data while in Apheis-3 we used corrected data.

Figure 16. PM_{10}: Short term (ST), cumulative short-term (DL), long term (LT) health impact on all causes mortality (ICD 9 < 800). Reductions to 20 µg/m^3. Number of deaths per 100 000 inhabitants.



If we now consider the second scenario, a reduction to 20 µg/m^3 in the long term[6] (2010 limit value not to be exceeded for PM_{10}), most of the cities would benefit from this reduction in corrected PM_{10} levels. All other things being equal, the corresponding reductions in the number of "premature" deaths per 100 000 inhabitants would be: 161 in Athens, 165 in Bucharest (including 25 and 51 related to short and cumulative short-term exposure[7]), 117 in Celje, 125 in Rome and 194 in Tel Aviv. The 23 cities that measured PM_{10} would average 60 "premature" deaths per 100 000 inhabitants. In all these cities, all other things being equal, the HIA estimated that 21 828 "premature" deaths could be prevented annually if long-term exposure to outdoor concentrations of corrected PM_{10} were reduced to 20 µg/m^3 in each city.

On the other hand, all other things being equal, a reduction to 20 µg/m^3 in short-term and cumulative short-term exposure to raw PM_{10} values would lead respectively to the following reductions in the number of "premature" deaths per 100 000 inhabitants: Athens 17 and 34, Bucharest 25 and 51, Celje 11 and 23, Rome 13 and 26, Tel Aviv 17 and 35.

In all the 23 cities, all other things being equal, the HIA estimated that 2 580 and 5 240 "premature" deaths could be prevented annually if short and cumulative short-term exposure to outdoor concentrations of raw PM_{10} were reduced to 20 µg/m^3 in each city.

Swedish cities (Gothenburg and Stockholm) already comply with this scenario.

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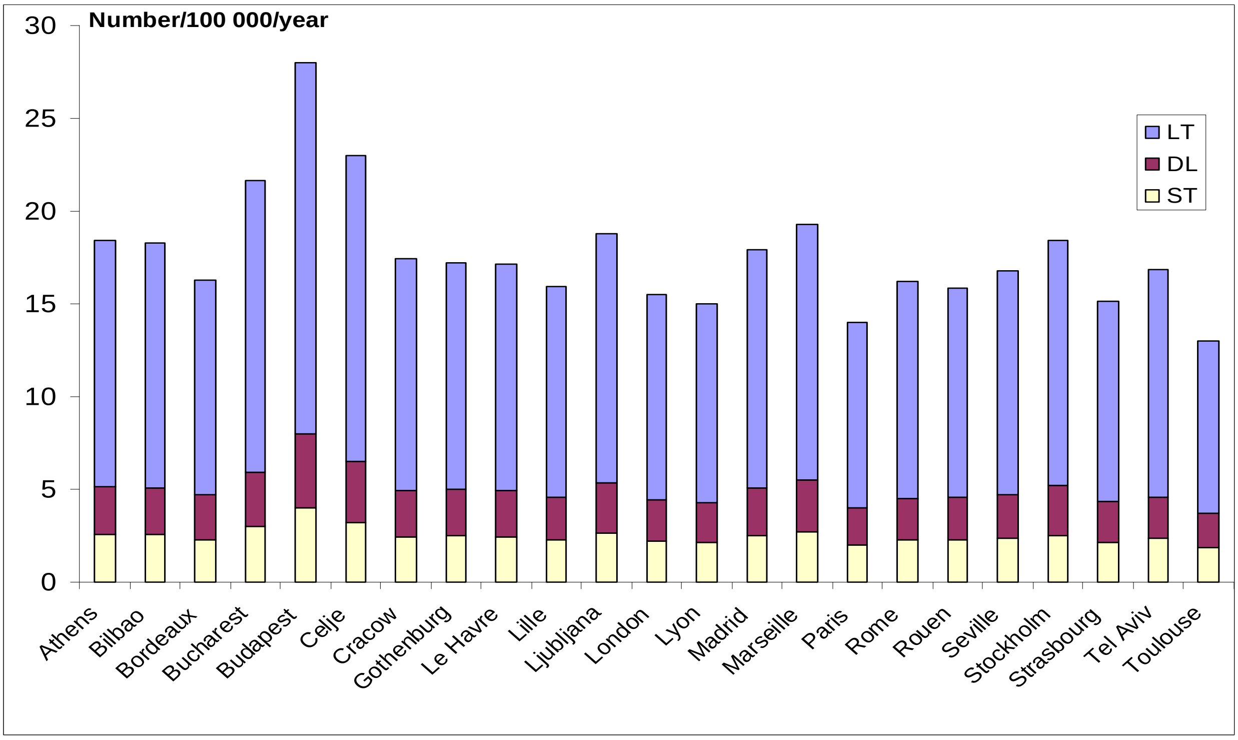
[6] For HIAs of long-term exposure, we had to correct the automatic PM_{10} measurements used by most of the cities by a specific correction factor (local or, by default, the European factor of 1.3) in order to compensate for losses of volatile particulate matter.

[7] For HIAs of short-term exposure, we used raw PM_{10} and BS levels measured directly at monitoring stations

Figure 17. PM_{10}: Short term (ST), cumulative short-term (DL), long term (LT) health impact on all-causes mortality (ICD 9 <800). Reductions by 5 µg/m^3. Number of deaths per 100 000 inhabitants.



If the annual mean of corrected PM_{10} values were reduced by 5 µg/m^3 in all the 23 cities, the consequent reduction in the number of "premature" deaths per 100 000 inhabitants would range between 28 in Budapest and 13 in Toulouse. These cities would average 17 "premature" deaths per 100 000 inhabitants in the 23 cities measuring PM_{10}.

In all the 23 cities, all other things being equal, the HIA estimated that 6 143 "premature" deaths could be prevented annually if long-term exposure to outdoor concentrations of corrected PM_{10} levels were reduced by 5 µg/m^3 in each city.

If daily mean raw values of PM_{10} were reduced by 5 µg/m^3 in all the cities, for short-term and cumulative short-term exposure scenarios, the consequent reduction in the number of "premature" deaths per 100 000 inhabitants would range respectively between 4 and 8 in Budapest and 2 and 4 in Toulouse.

For all the cities, all other things being equal, the HIA estimated respectively that 868 and 1 739 "premature" deaths related to short-term and cumulative short-term exposure could be prevented annually if raw outdoor concentrations of PM_{10} were reduced by 5 µg/m^3 in each city.

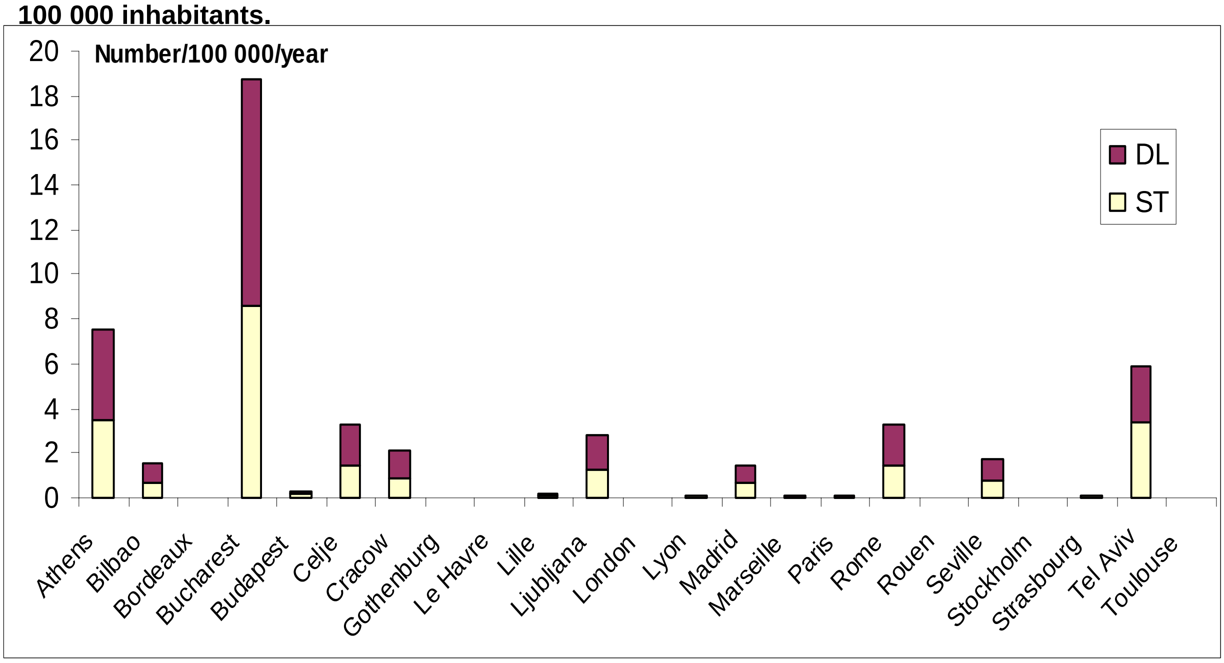
Note that most, but not all, the potential benefits of reducing short-term and cumulative short-term exposure to PM_{10} are included in the benefits of reducing long-term exposure.

2. PM_{10}: Short and cumulative short-term impacts on cardiovascular mortality (ICD9 390-459)

In Apheis-3, the HIA assessed not only total mortality but also cause-specific mortality.

Figure 18 shows the potential benefits, in the short-term and cumulative short-term exposure, of reducing raw PM_{10} levels to a 24-hour value of 50 µg/m^3 (2005 and 2010 limit values) on all days exceeding this value. No exposure-response functions were available for HIAs of long-term exposure to PM_{10} on cardiovascular mortality.

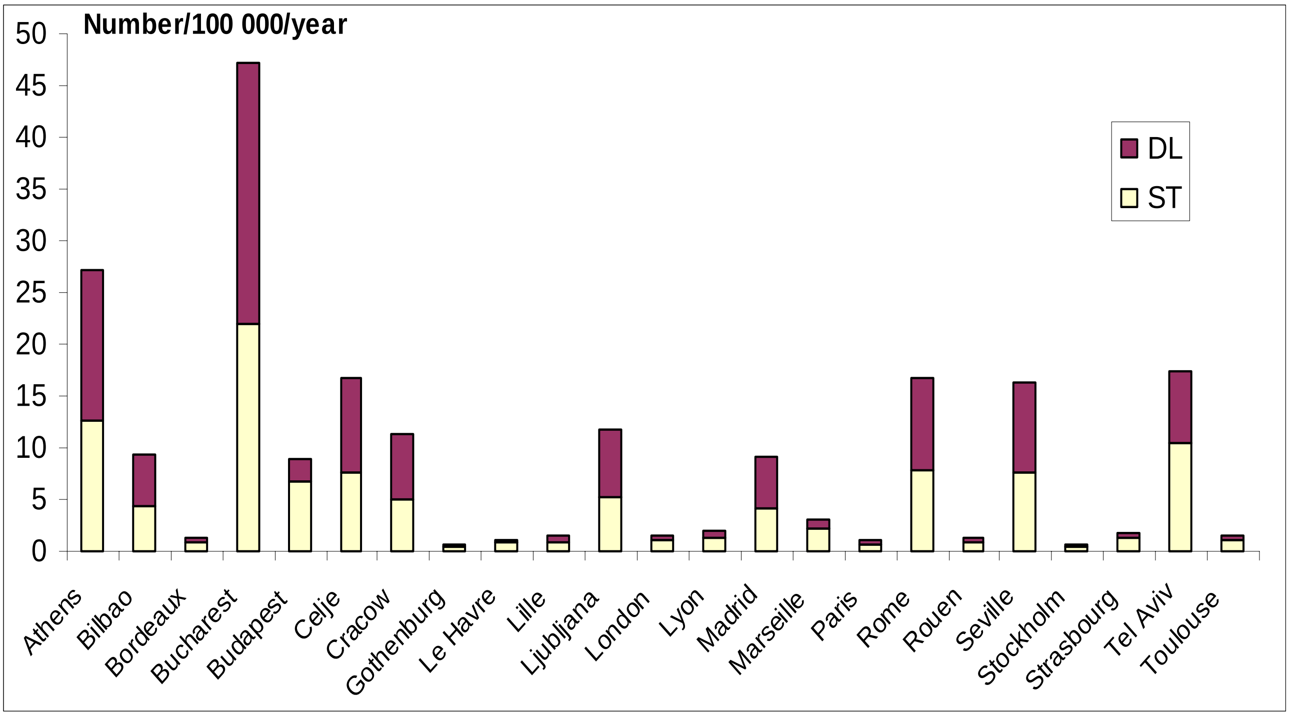
Figure 18. PM_{10}: Short term (ST) and cumulative short-term (DL) health impact on cardiovascular mortality (ICD9 390-459**). Reductions to 50 µg/m^3. Number of deaths per 100 000 inhabitants.**



If PM_{10} levels for all days when they exceeded this value were reduced to 50 µg/m^3 in the 23 cities that measured PM_{10}, all other things being equal, cumulative short-term impact would be reduced respectively by almost 8 "premature" cardiovascular deaths per 100 000 inhabitants in Athens (including 3 related to a very short-term exposure), 19 in Bucharest (including 8 related to a very short-term exposure), and 6 in Tel Aviv (including 3 related to a very short-term exposure). Celje, Ljubljana and Rome would benefit from a reduction of around 3 "premature" cardiovascular deaths per 100 000 inhabitants. Bilbao, Cracow, Madrid and Seville would benefit from a reduction of around 2 "premature" cardiovascular deaths per 100 000 inhabitants. The 23 cities would average 2 "premature" cardiovascular deaths per 100 000 inhabitants.

In all the 23 cities, all other things being equal, the HIA estimated that 877 "premature" cardiovascular deaths (including 412 related to very short-term exposure) could be prevented annually if cumulative short-term and short-term exposure to outdoor concentrations of PM_{10} were reduced to 50 µg/m^3 in each city.

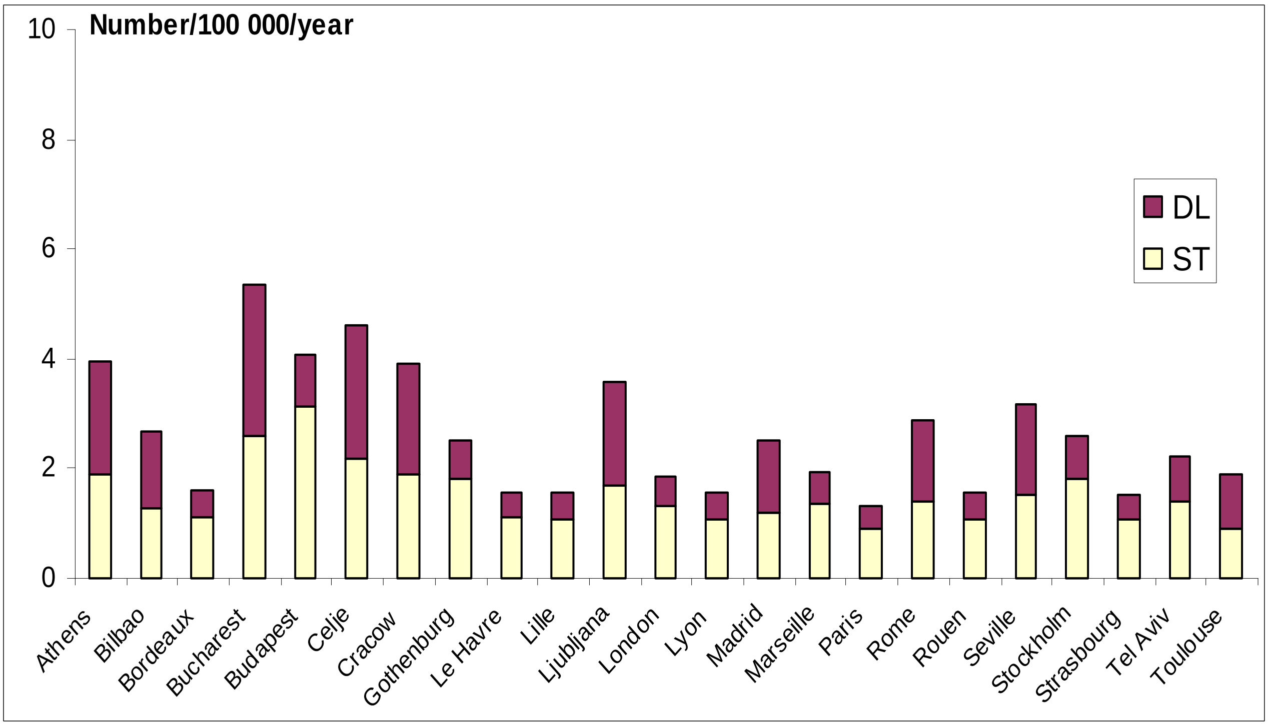
Figure 19. PM_{10}: Short term (ST) and cumulative short-term (DL) health impact on cardiovascular mortality (ICD9 390-459). Reductions to 20 µg/m^3. Number of deaths per 100 000 inhabitants



If we now consider a reduction in daily mean values of PM_{10} to 20 µg/m^3 (2010 limit values for PM_{10}) in the 23 cities that measured PM_{10}, all other things being equal, the corresponding reductions in the number of "premature" cardiovascular deaths per 100 000 inhabitants would be: 27 in Athens (including 13 related to very short-term exposure to PM_{10}), 47 in Bucharest (including 22 related to a very short-term exposure), 17 in Celje (including 8 related to short-term exposure), 17 in Rome (including 8 related to a very short-term exposure), 16 in Seville (including 8 related to a very short-term exposure) and 18 in Tel Aviv (including 11 related to a very short-term exposure to PM_{10}). The 23 cities would average 10 "premature" deaths per 100 000 inhabitants.

In all the 23 cities, all other things being equal, the HIA estimated that 3 458 "premature" cardiovascular deaths (including 1 741 related to very short-term exposure) could be prevented annually if cumulative short-term and short-term exposure to outdoor concentrations of PM_{10} were reduced to 20 µg/m^3 in each city.

Figure 20. PM_{10}: Short term (ST) and cumulative short-term (DL) health impact on cardiovascular mortality (ICD9 390-459). Reductions by 5 µg/m^3. Number of deaths per 100 000 inhabitants

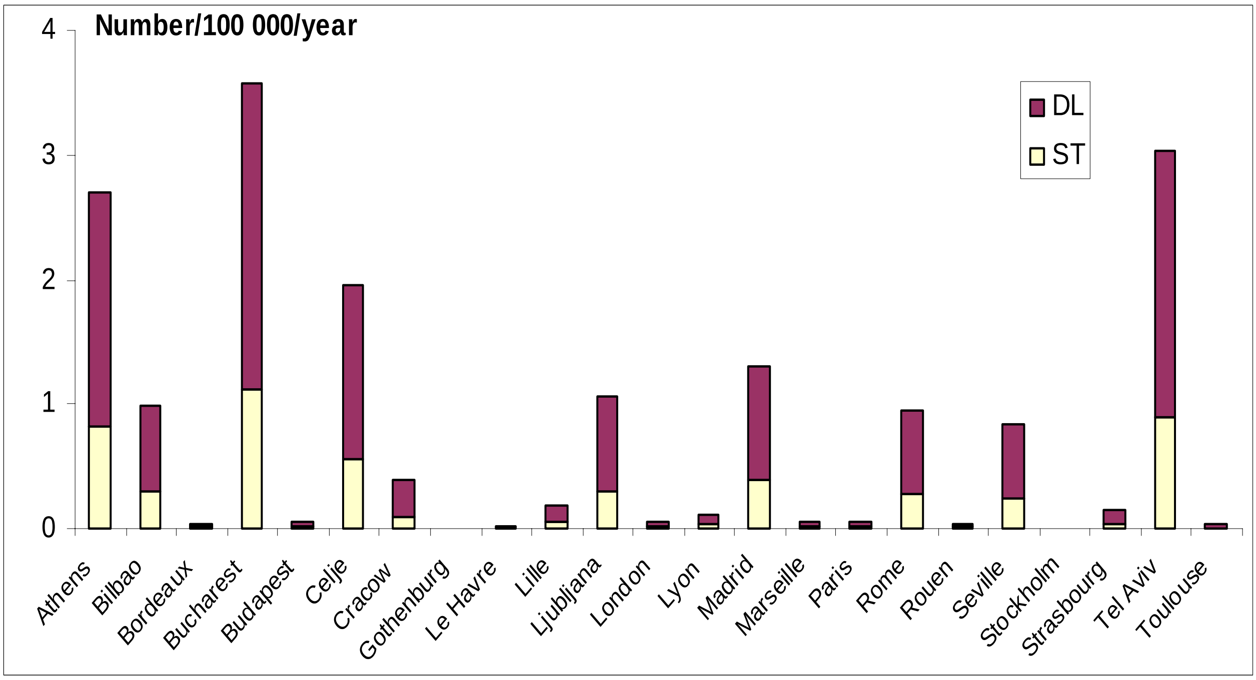


If daily mean values of PM_{10} were reduced by 5 µg/m^3 in all the 23 cities that measured PM_{10}, all other things being equal, the consequent reduction in the number of "premature" cardiovascular deaths per 100 000 inhabitants would range between 1.3 in Paris (including 1 death related to very short-term exposure to PM_{10}) and 5 in Bucharest (including almost 3 related to short -term exposure). The 23 cities would average 2 «premature» deaths per 100 000 inhabitants.

In all the 23 cities, all other things being equal, the HIA estimated that 897 "premature" cardiovascular deaths (including 527 related to very short-term exposure), could be prevented annually if cumulative short-term and short-term exposure to outdoor concentrations of PM_{10} were reduced by 5 µg/m^3 in each city.

3. PM_{10}: Short and cumulative short-term impacts on respiratory mortality (ICD9 390-459)

Figure 21. PM_{10}: Short term (ST) and cumulative short-term (DL) health impact on respiratory mortality (ICD9 460-519**). Reductions to 50 µg/m^3. Number of deaths per 100 000 inhabitants**

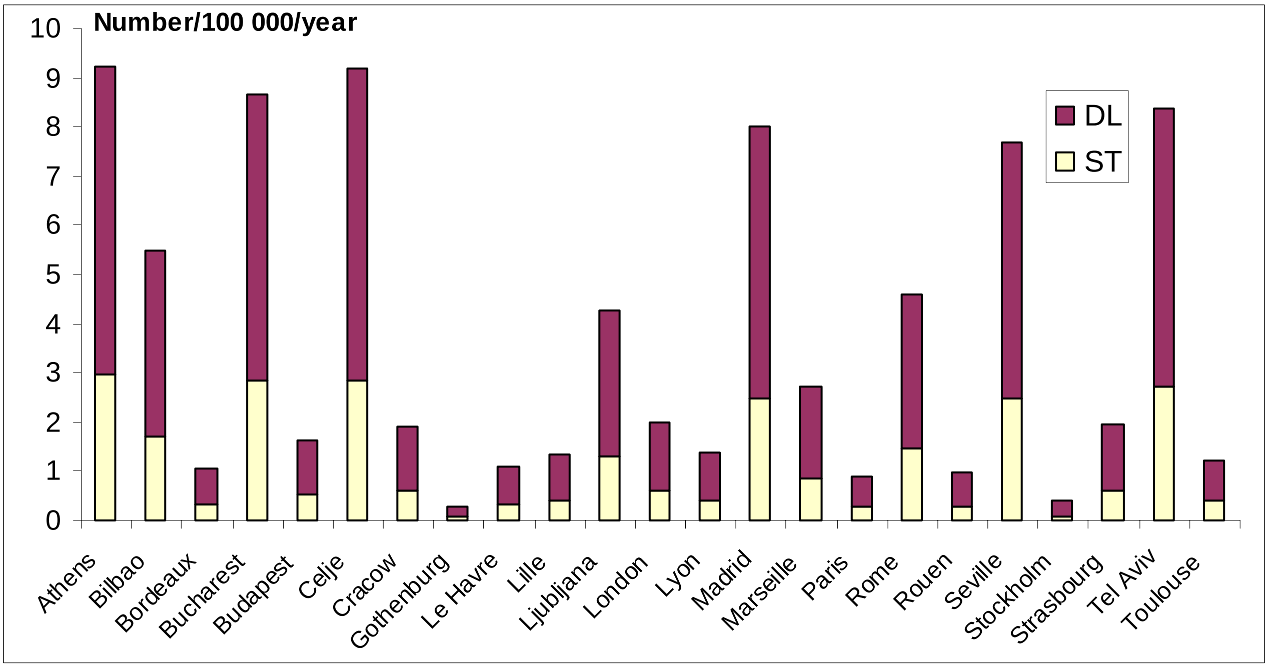


If PM_{10} levels for all days when they exceeded this value were reduced to 50 µg/m^3 in the 23 cities that measured PM_{10}, all other things being equal, the cumulative short-term impact would be reduced respectively by almost 3 "premature" respiratory deaths per 100 000 inhabitants in Athens (including almost 1 related to a very short-term exposure), almost 4 in Bucharest (including 1 related to a very short-term exposure), almost 2 in Celje (including 0.5 related to a very short-term exposure) and 3 in Tel Aviv (including 1 related to a very short-term exposure).

The 23 cities would average 1 "premature" respiratory death per 100 000 inhabitants.

In all the 23 cities, all other things being equal, the HIA estimated that 288 "premature" respiratory deaths (including 87 related to very short-term exposure) could be prevented annually if cumulative short-term exposure and short-term exposure to outdoor concentrations of PM_{10} were reduced to 50 µg/m^3 in each city.

Figure 22. PM_{10}: Short term (ST) and cumulative short-term (DL) health impact on respiratory mortality (ICD9 460-519). Reductions to 20 µg/m^3. Number of deaths per 100 000 inhabitants

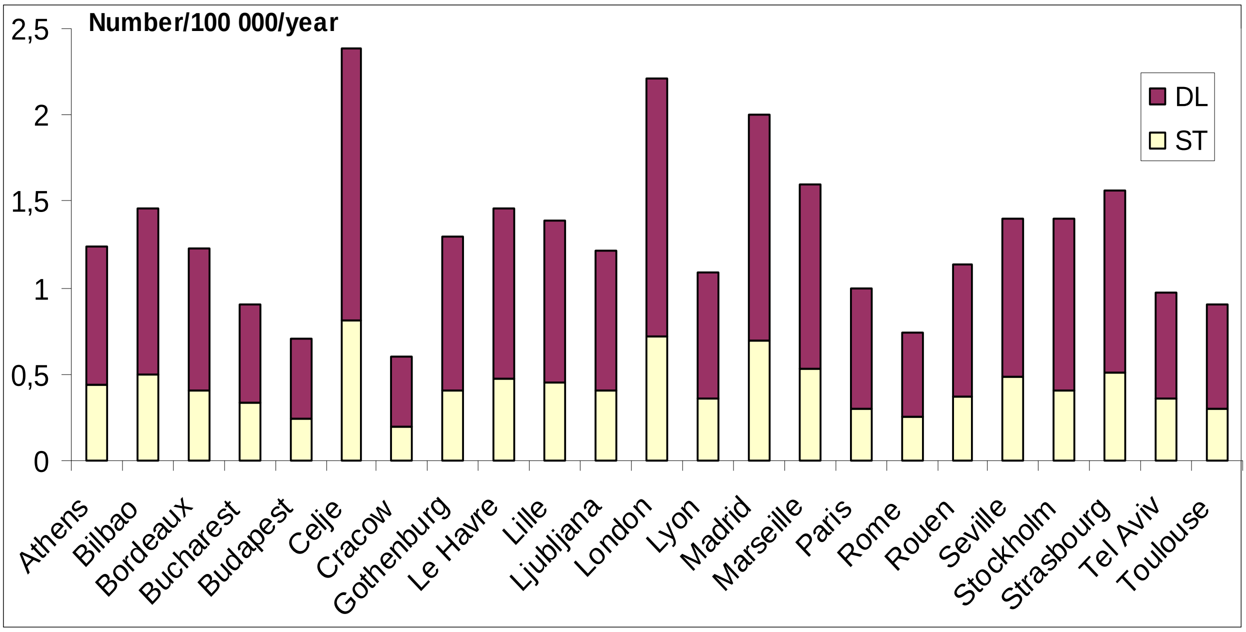


If we now consider a reduction in daily mean values of PM_{10} to 20 µg/m^3 (2010 limit values for PM_{10}) in the 23 cities that measured PM_{10}, all other things being equal, the corresponding reductions in the number of "premature" respiratory deaths per 100 000 inhabitants would be: 9 in Athens and Celje (including almost 3 related to very short-term exposure to PM_{10}), 8.7 in Bucharest (including 2.8 related to a very short-term exposure), 4 in Ljubljana (including 1.3 related to a very short-term exposure), 4.6 in Rome (including 1.5 related to a very short-term exposure), 7.7 in Seville (including 2.5 related to a very short-term exposure and 8.4 in Tel Aviv (including 2.7 related to a very short-term exposure to PM_{10}).

The 23 cities would average four "premature" respiratory deaths per 100 000 inhabitants.

In all the 23 cities, all other things being equal, the HIA estimated that 1 348 "premature" respiratory deaths (including 429 related to very short-term exposure) could be prevented annually if cumulative short-term and short-term exposure to outdoor concentrations of PM_{10} were reduced to 20 µg/m^3 in each city.

Figure 23. PM_{10}: Short term (ST) and cumulative short-term (DL) health impact on respiratory mortality (ICD9 460-519). Reductions by 5 µg/m^3. Number of deaths per 100 000 inhabitants



If daily mean values of PM_{10} were reduced by 5 µg/m^3 in all the 23 cities that measured PM_{10}, all other things being equal, the consequent reduction in the number of "premature" respiratory deaths per 100 000 inhabitants would be the highest, between 2 and 2.5 in Celje, London and Madrid (including almost 1 death related to a very short-term exposure to PM_{10}).

The 23 cities would average 1 "premature" respiratory death per 100 000 inhabitants.

In all the 23 cities, all other things being equal, the HIA estimated that 489 "premature" respiratory deaths (including 162 related to very short-term exposure) could be prevented annually if cumulative short-term and short-term exposure to outdoor concentrations of PM_{10} were reduced by 5 µg/m^3 in each city.

For each city, the following map shows the cumulative short-term health impact for up to 40 days on total, cardiovascular and respiratory mortality for a reduction in PM_{10} levels to 20 µg/m^3 expressed in number of deaths per 100,000 inhabitants

Map of cumulative short-term impact (up to 40 days) on total, cardiovascular and respiratory mortality for a reduction to 20 µg/m^3 in PM_{10} levels. Number of deaths per 100 000 inhabitants

4. PM_{10}: Meta-analytic vs shrunken estimated number of cases

The value of different estimates to assess the relationship between particulate pollution and acute mortality and its consequences for HIA was investigated by the Apheis Statistical Advisory Group (Appendix 5).

Applying the so-called shrunken estimate in Athens or in Cracow would lead to almost 100% more “premature” deaths or 40% less deaths respectively than those calculated with the overall meta-analytic estimate in the scenario reducing PM_{10} by 5µg/m^3. This shrunken estimate has the property to derive the overall estimate at the local level by combining information from the city-specific estimate with the overall one and can be considered as a weighted mean between these two estimates.

The impact is quite different when one looks at reducing PM_{10} levels to a certain point, for instance to 20 or 50 µg/m^3. Not every city can contribute to these scenarios, i.e. cities with levels of particulate pollution already below these levels will not contribute at all. The overall mean is then driven by cities with the highest particulate pollution levels. In this small sample, reducing PM_{10} levels to 50 µg/m^3, using shrunken estimates would lead to 58% more “premature” deaths on average than using the overall estimate, and 42% for a reduction to 20µg/m^3.

Figure 24. PM_{10}: Meta-analytic vs shrunken estimated health impact on all-causes mortality (ICD9 < 800; ICD10 A00-Q99). Reductions to 50 µg/m^3. Number of deaths per 100 000 inhabitants

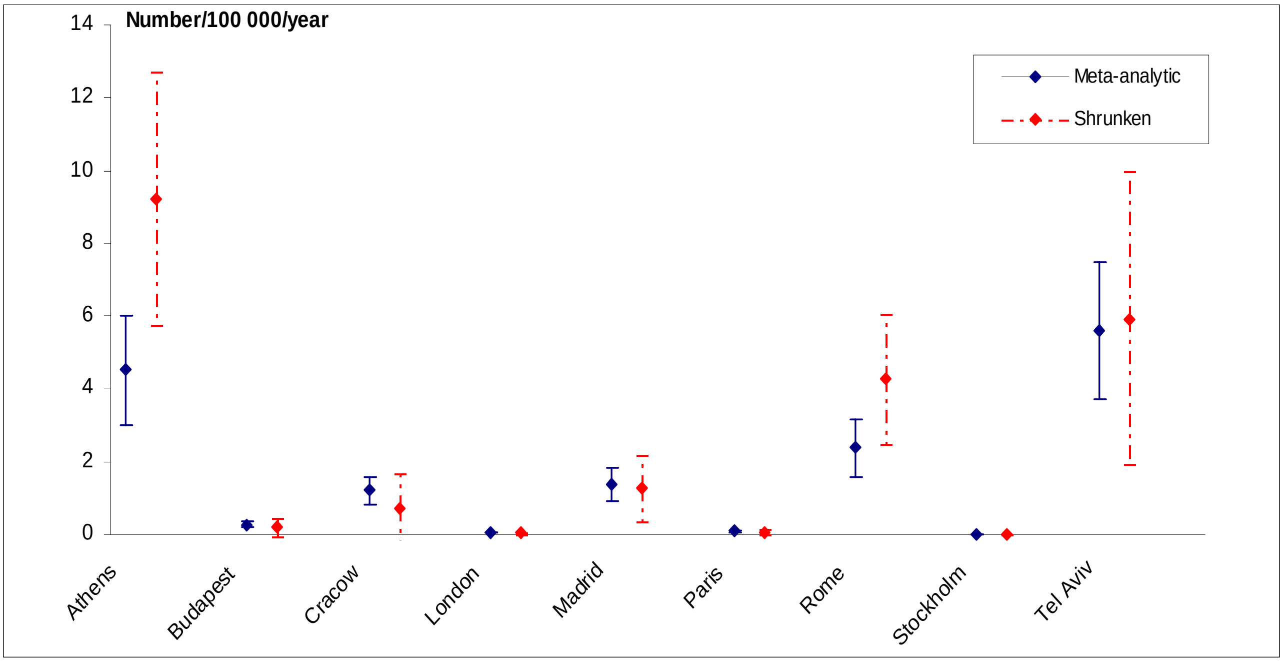


Figure 25. PM_{10}: Meta-analytic vs shrunken estimated health impact on all-causes mortality (ICD9 < 800; ICD10 A00-Q99). Reductions to 20 µg/m^3. Number of deaths per 100 000 inhabitants

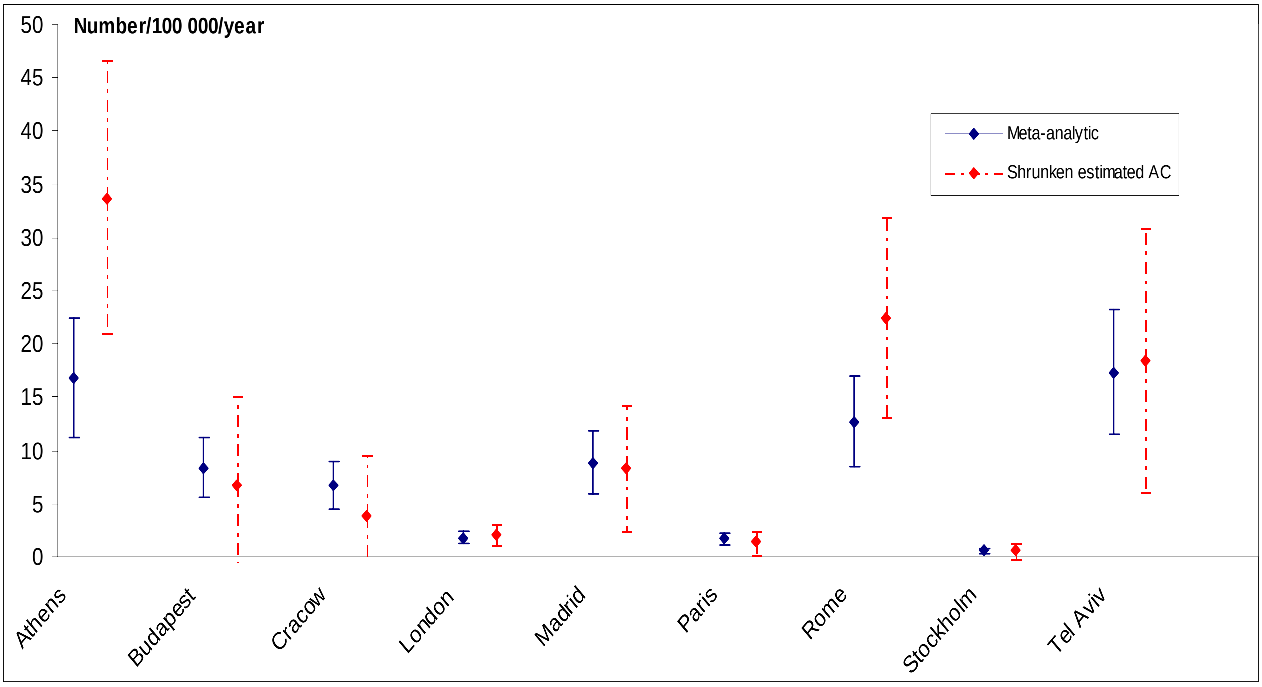
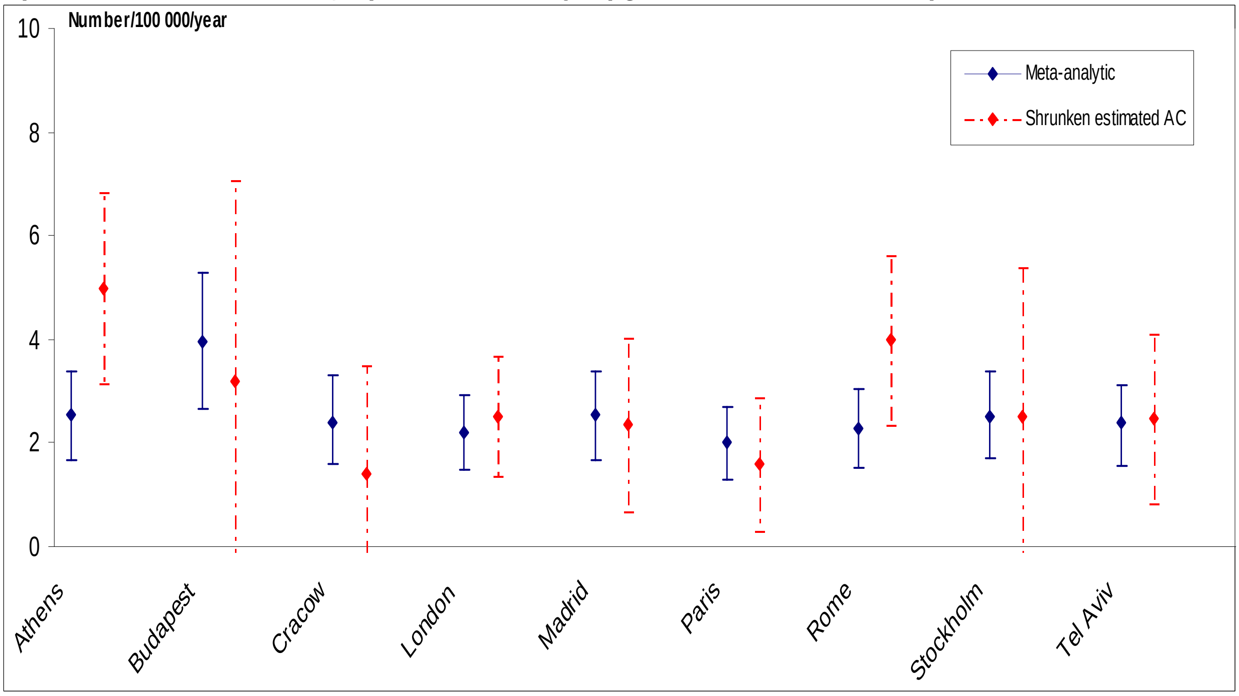


Figure 26. PM_{10}: Meta-analytic vs shrunken estimated health impact on all causes mortality (ICD9 < 800; ICD10 A00-Q99). Reductions by 5 µg/m^3. Number of deaths per 100 000 inhabitants



A discussion of the use of different estimates and its consequences for HIAs appears in the "Interpretation of findings" section.

$PM_{2.5}$ findings

For the first time in Apheis, we conducted HIAs of long-term exposure to $PM_{2.5}$. To contribute to the current discussions within the EC legislation process on the limit values[8] to be attributed to $PM_{2.5}$, we conducted our HIA for the following chronic-effect scenarios.

For long-term exposure to $PM_{2.5}$, we used average estimates of the more recent ACS study (Pope, 2002) that provided E-R functions for the following health outcomes: all-causes mortality, cardiopulmonary mortality and lung-cancer mortality.

HIAs of long-term exposure to $PM_{2.5}$ were conducted converting corrected PM_{10} values by a local or European default value (see “Methods” section).

Chronic effects scenarios

We used three scenarios to estimate the chronic effects of long-term exposure to $PM_{2.5}$ on total and cause-specific mortality over a 1-year period:

- reduction of the annual mean value of $PM_{2.5}$ to a level of 20 µg/m^3
- reduction of the annual mean value of $PM_{2.5}$ to a level of 15 µg/m^3
- reduction by 3.5 µg/m^3 of the annual mean value of $PM_{2.5}$ (equivalent to 5 µg/m^3 in PM_{10} using the European conversion factor 0.7).

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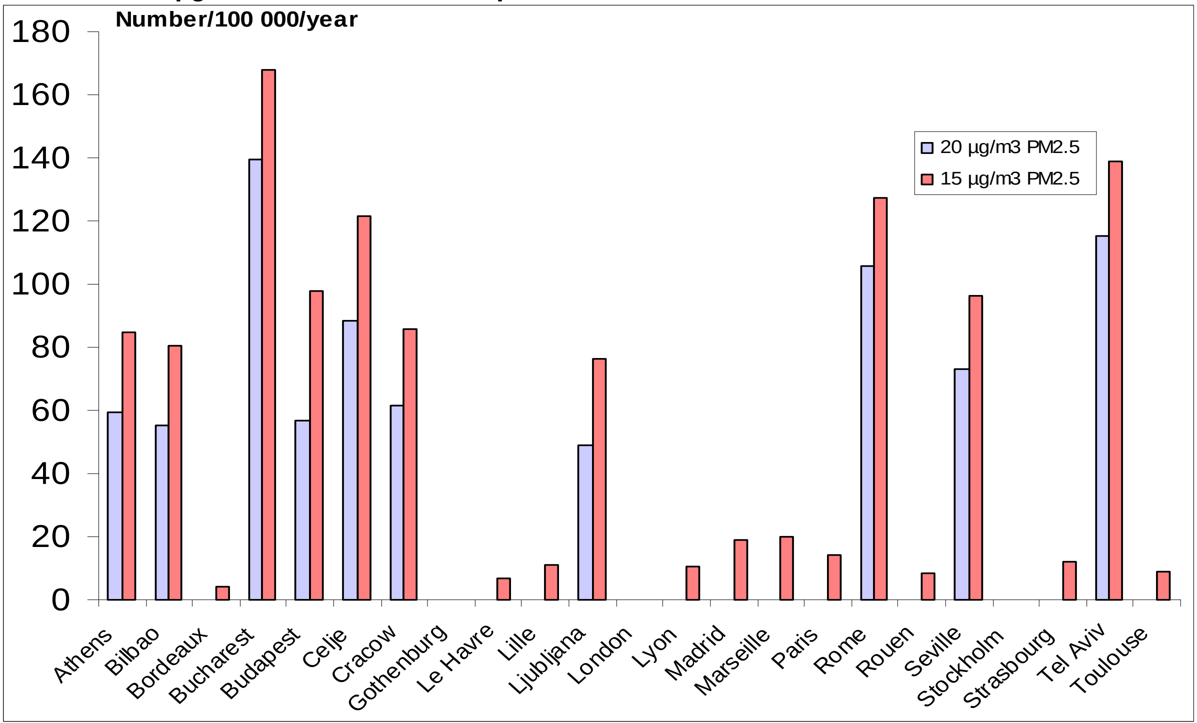
[8] http://europa.eu.int/comm/environment/air/café/index.htm)

1. $PM_{2.5}$: Long-term impact on total mortality

The following figures show the impact of long-term exposure to converted $PM_{2.5}$ levels for different scenarios of $PM_{2.5}$ reductions in terms of number of "premature" deaths for all causes mortality, cardiopulmonary and lung-cancer mortality.

Please note that in figures 27, 29 and 31 the bars are slightly shifted to the right and that some cities have only one or no bars because they already show values of $PM_{2.5}$ below 20 or 15 $\mu g/m^3$, and do not show any health benefit in these scenarios.

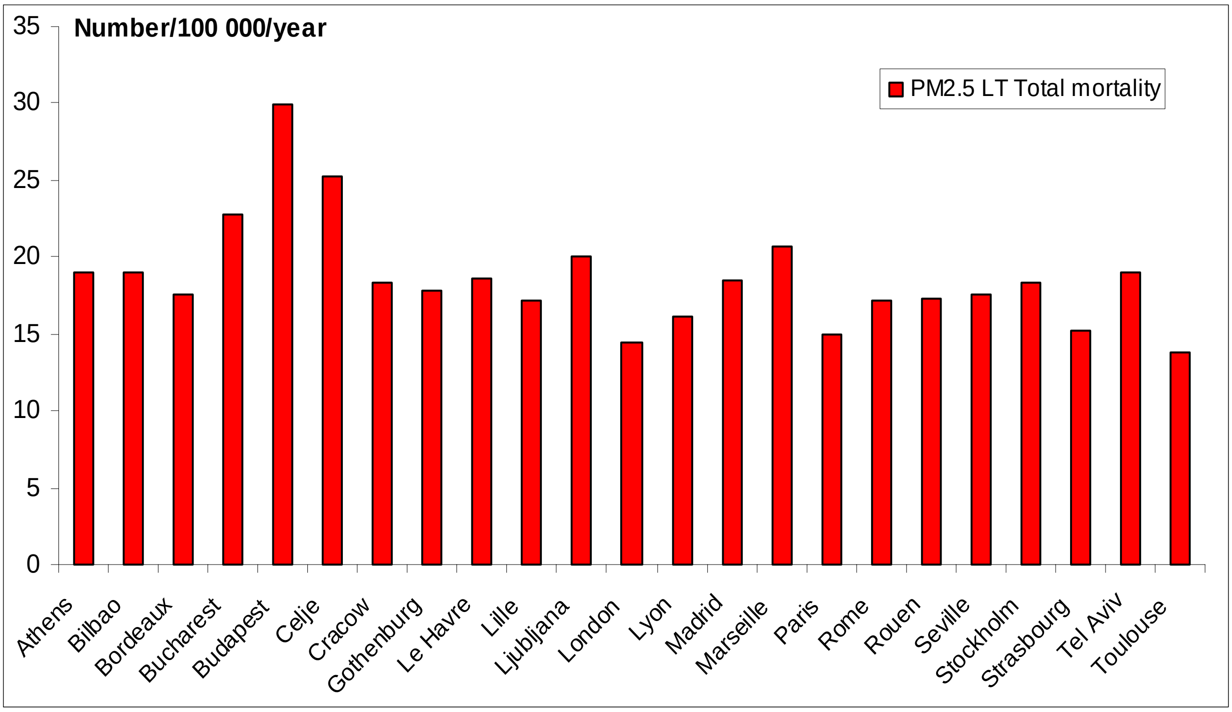
Figure 27. $PM_{2.5}$: Long term (LT) health impact on all-causes mortality (ICD 9 0-999). Reductions to 20 and 15 $\mu g/m^3$. Number of deaths per 100 000 inhabitants



If the annual mean of converted $PM_{2.5}$ values were reduced to 20 or 15 $\mu g/m^3$ in the 23 cities that measured $PM_{10,}$ all other things being equal, the consequent reduction in the number of "premature" deaths per 100 000 inhabitants would be respectively: 140/168 in Bucharest, 115/139 in Tel Aviv, 106/127 in Rome, 88/122 in Celje, 73/96 in Seville, 62/86 in Cracow, 60/85 in Athens, 57/98 in Budapest, 55/80 in Bilbao and 49/76 in Ljublana. All other cities would only benefit for a reduction to 15 $\mu g/m^3$, excepting the Swedish cities (Gothenburg, Stockholm), which are already below these levels of $PM_{2.5}$. The 23 cities would average 32 "premature" deaths per 100 000 inhabitants for a reduction to 20 $\mu g/m^3$ in converted $PM_{2.5}$ values. This average would be 47 "premature" deaths per 100 000 inhabitants if the reduction were to 15 $\mu g/m^3$.

For all the 23 cities, all other things being equal, the HIA estimated that 11 375 "premature" deaths could potentially be prevented annually if long-term exposure to converted $PM_{2.5}$ levels were reduced to 20 $\mu g/m^3$ in each city. There would be 16 926 "premature" deaths if long-term exposure to converted $PM_{2.5}$ levels were reduced to 15 $\mu g/m^3$.

Figure 28. $PM_{2.5}$: Long term (LT) health impact on all-causes mortality (ICD 9 0-999). Reductions by 3.5 µg/m^3. Number of deaths per 100 000 inhabitants



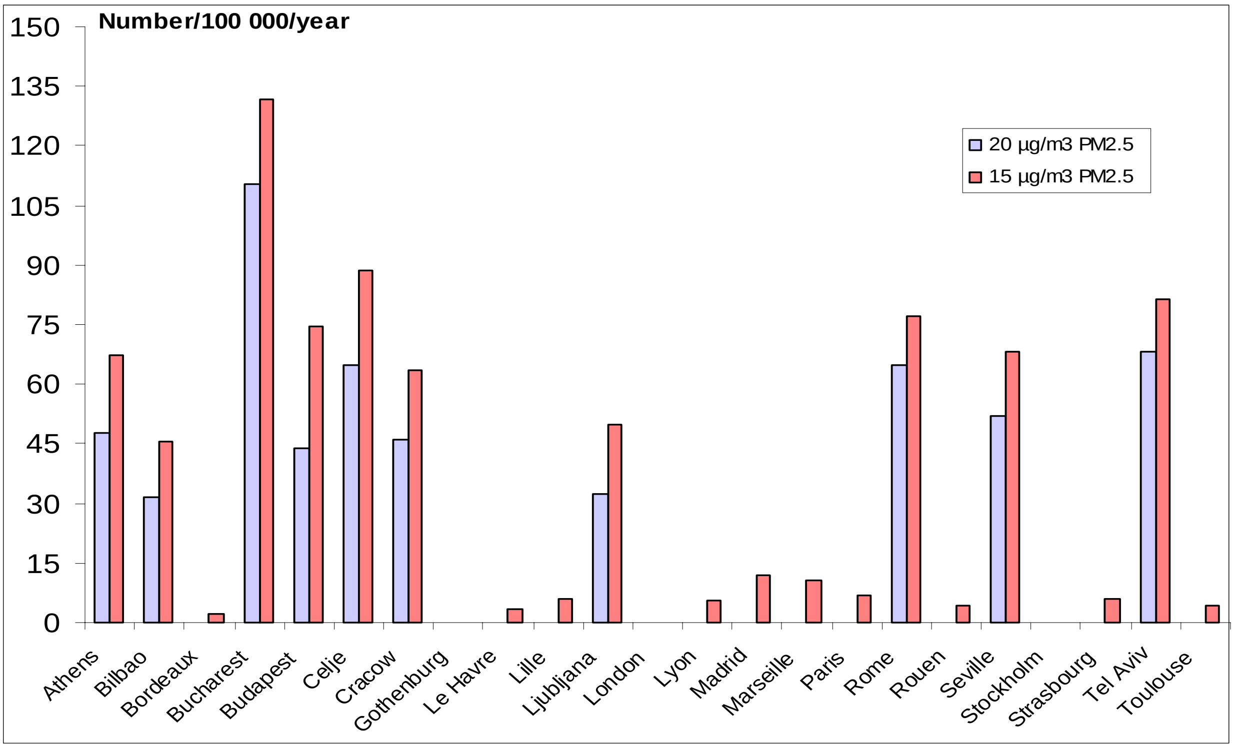
If the annual mean of converted $PM_{2.5}$ values were reduced by 3.5 µg/m^3 (equivalent to 5 µg/m^3 for PM_{10}) in the 23 cities that measured PM_{10}, all other things being equal, the consequent reduction in the number of "premature" deaths per 100 000 inhabitants would be the highest in Budapest, Celje and Bucharest.

The 23 cities, including the Swedish ones, would average 18 "premature" deaths per 100 000 inhabitants for all the cities.

For all the 23 cities, all other things being equal, the HIA estimated that 6 355 «premature» deaths could be prevented annually if long-term exposure to converted $PM_{2.5}$ levels were reduced by 3.5 µg/m^3 in each city.

2. $PM_{2.5}$: Long-term impact on cardiopulmonary mortality (ICD9 401-440 and 460-519)

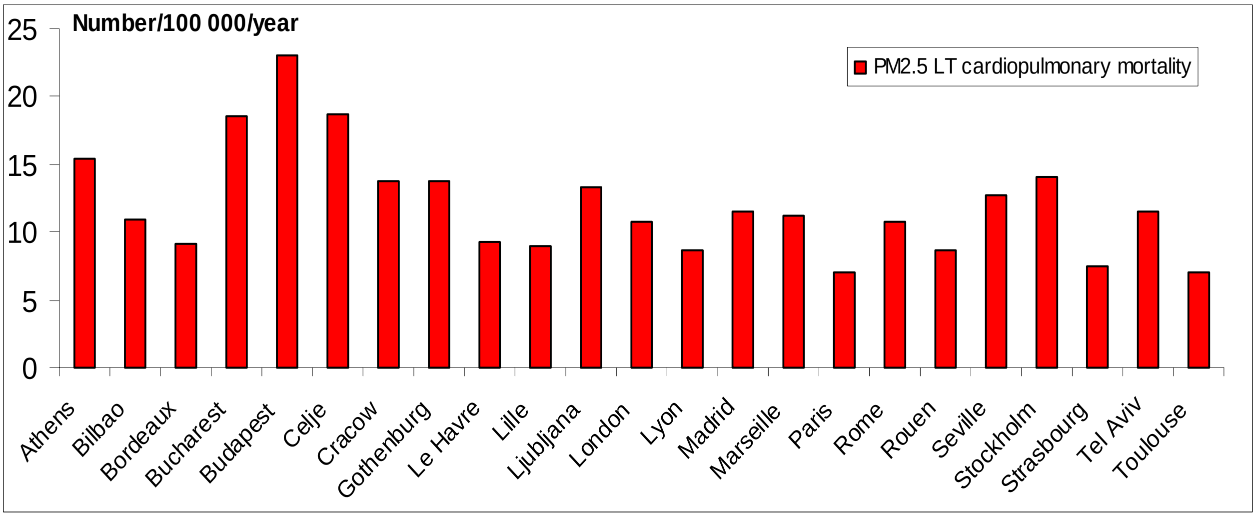
Figure 29. $PM_{2.5}$: Long term (LT) health impact on cardiopulmonary mortality (ICD9 401-440 and 460-519). Reductions to 20 and 15 µg/m^3. Number of deaths per 100 000 inhabitants



For cardiopulmonary mortality, all other things being equal, if the annual mean of converted $PM_{2.5}$ values were reduced to 20 or to 15 µg/m^3 in the 23 cities that measured PM_{10}, the consequent reduction in the number of "premature" cardiopulmonary deaths per 100 000 inhabitants would be respectively: 110/130 in Bucharest, 68/82 in Tel Aviv, 65/88 in Celje, 65/77 in Rome, 52/68 in Seville, 46/64 in Cracow, 48/67 in Athens, 44/75 in Budapest, 31/45 in Bilbao and 32/50 in Ljublana. Again, all other cities would only benefit from a reduction to 15 µg/m^3, excepting the Swedish cities (Gothenburg, Stockholm), which are already below these levels of $PM_{2.5}$. The 23 cities would average 22 "premature" cardiopulmonary deaths per 100 000 inhabitants for a reduction to 20 µg/m^3 in converted $PM_{2.5}$ values. This average would be 32 "premature" cardiopulmonary deaths per 100 000 inhabitants if the reduction were to 15 µg/m^3.

For all the 23 cities, all other things being equal, the HIA estimated that 8 053 "premature" cardiopulmonary deaths might be prevented annually if long-term exposure to converted $PM_{2.5}$ levels were reduced to 20 µg/m^3 in each city. There would be 11 612 "premature" cardiopulmonary deaths if long-term exposure to converted $PM_{2.5}$ levels were reduced to 15 µg/m^3.

Figure 30. $PM_{2.5}$: Long term (LT) health impact on Cardiopulmonary mortality (ICD9 401-440 and 460-519. Reductions by 3.5 µg/m^3. Number of deaths per 100 000 inhabitants

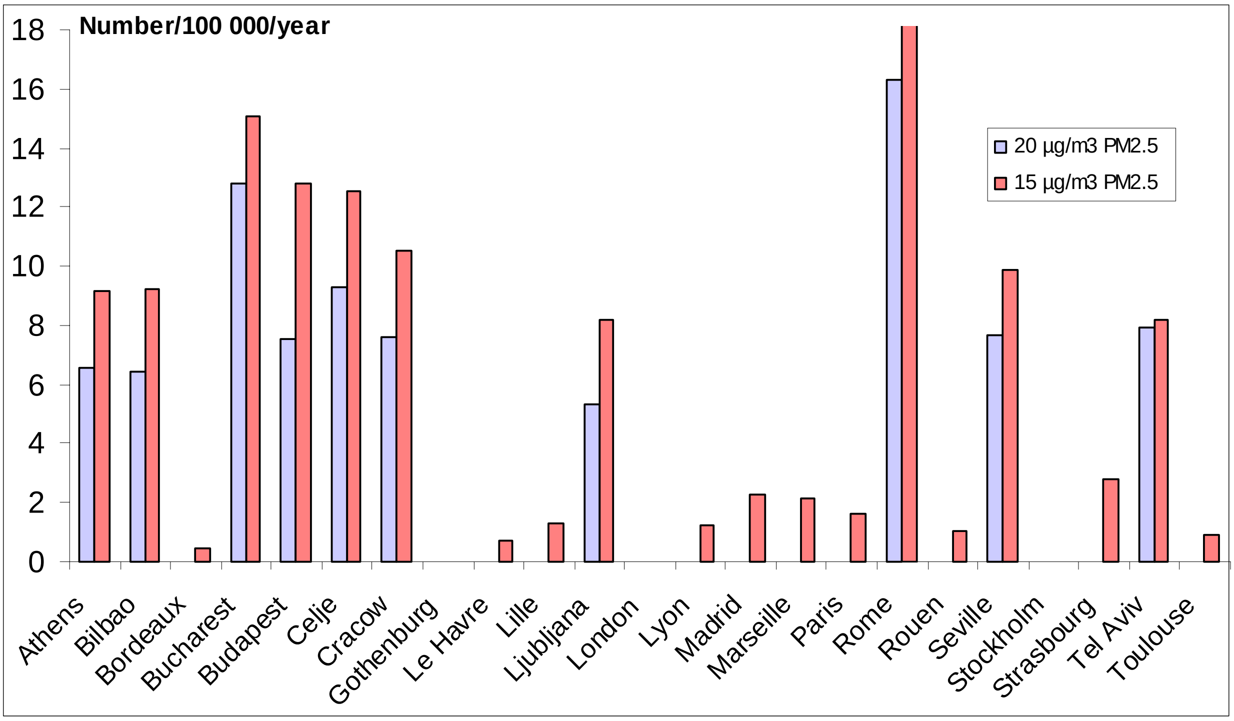


If the annual mean of converted $PM_{2.5}$ values were reduced by 3.5 µg/m^3 in the 23 cities that measured PM_{10}, all other things being equal, the consequent reduction in the number of "premature" cardiopulmonary deaths per 100 000 inhabitants would be the highest in Budapest, Celje, Bucharest and Athens. The 23 cities would average 12 "premature" cardiopulmonary deaths per 100 000 inhabitants.

In all the 23 cities, all other things being equal, the HIA estimated that 4 199 "premature" cardiopulmonary deaths could be prevented annually if long-term exposure to converted $PM_{2.5}$ values were reduced by 3.5 µg/m^3 in each city.

3. $PM_{2.5}$: Long-term impact on lung-cancer mortality (ICD9 162)

Figure 31. $PM_{2.5}$: Long term (LT) health impact on lung cancer mortality (ICD9 162). Reductions to 20 and 15 µg/m^3. Number of deaths per 100,000 inhabitants

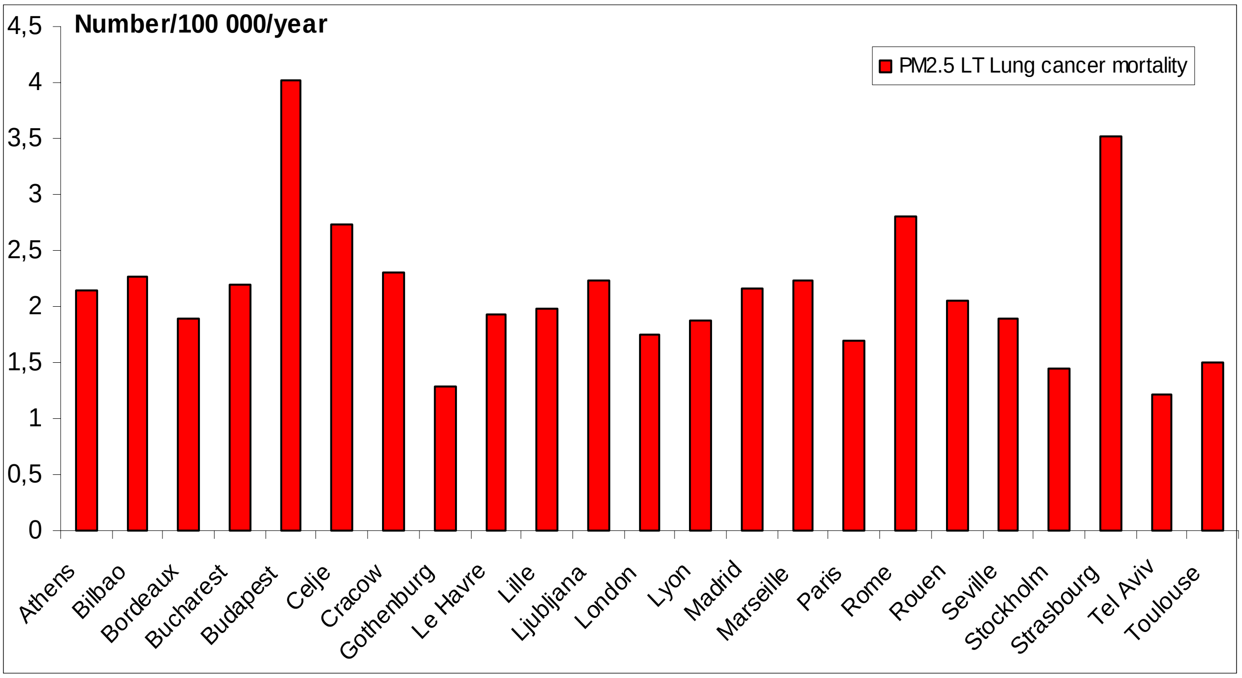


All other things being equal, if the annual mean of converted $PM_{2.5}$ values did not exceed 20 or 15 µg/m^3 in the 23 cities that measured PM_{10}, the number of "premature" lung-cancer deaths per 100 000 inhabitants would be reduced (with a certain delay) respectively by: 13/15 in Bucharest, 8/8 in Tel Aviv, 9/13 in Celje, 16/19 in Rome, 8/13 in Budapest, 8/10 in Seville and Cracow, 7/9 in Athens, 6/9 in Bilbao and 5/8 in Ljublana. All other cities would only benefit from a reduction to 15 µg/m^3, excepting Swedish cities (Gothenburg, Stockholm) and London, which are already below these levels of $PM_{2.5}$.

The 23 cities would average 4 "premature" lung-cancer deaths per 100 000 inhabitants if the annual mean of converted $PM_{2..5}$ values did not exceed 20 µg/m^3. This average would be 5 "premature" lung-cancer deaths per 100 000 inhabitants if the annual mean of converted $PM_{2..5}$ values did not exceed 15 µg/m^3.

In all the 23 cities, all other things being equal, the HIA estimated that 1 296 "premature" lung-cancer deaths might be prevented annually if long-term exposure to converted $PM_{2.5}$ levels did not exceed 20 µg/m^3 in each city. There would be 1 901 "premature" lung-cancer deaths if long-term exposure to converted $PM_{2.5}$ levels did not exceed 15 µg/m^3.

Figure 32. $PM_{2.5}$: Long term (LT) health impact on lung cancer mortality (ICD9 162). Reductions by 3.5 µg/m^3. Number of deaths per 100 000 inhabitants

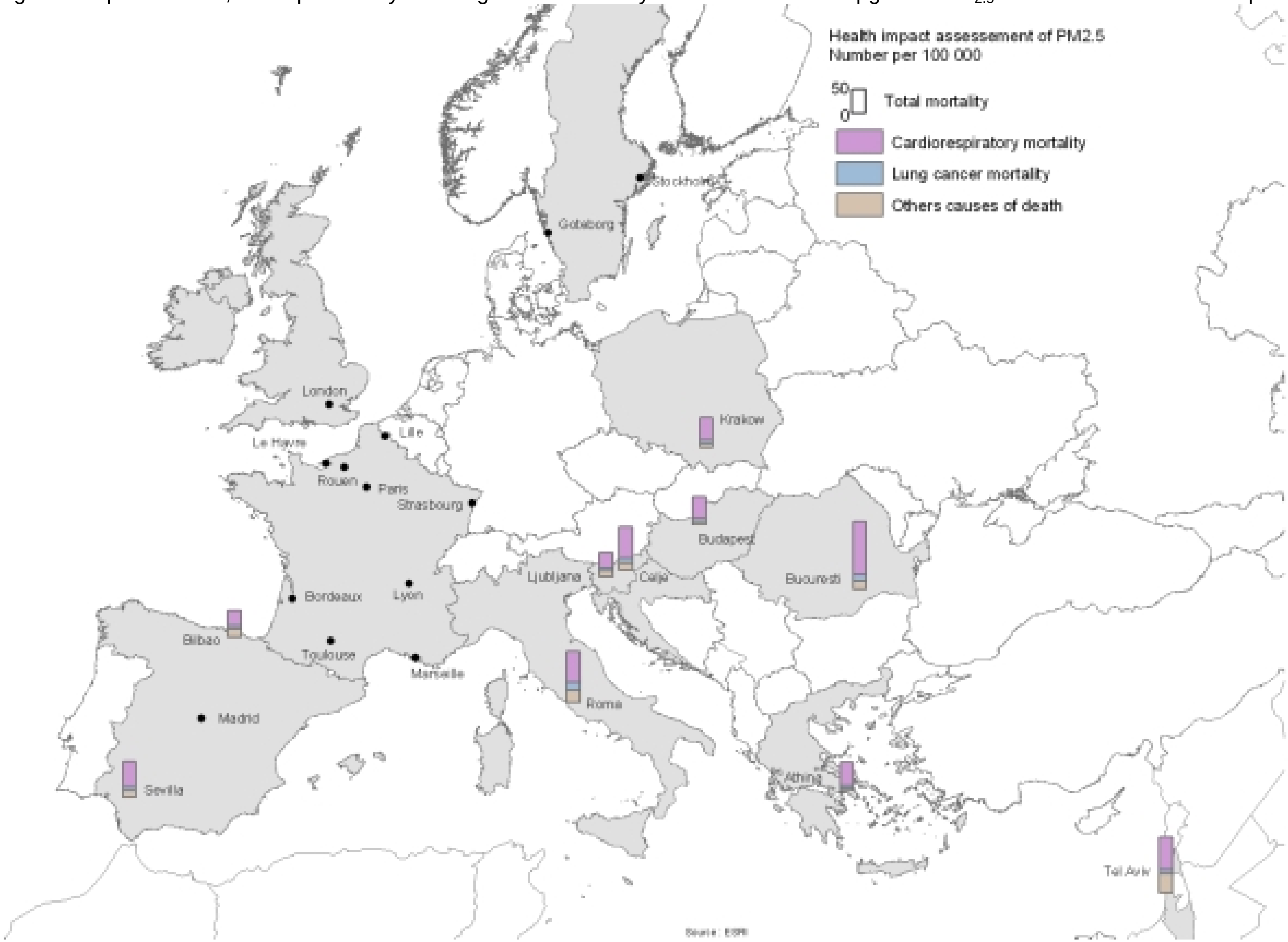


If the annual mean of converted $PM_{2.5}$ values were reduced by 3.5 µg/m^3 (equivalent to 5 µg/m^3 for PM_{10}) in the 23 cites that measured PM_{10}, all other things being equal, the consequent reduction (with a certain delay) in the number of "premature" lung-cancer deaths per 100 000 inhabitants would be the highest in Budapest, Strasbourg, Rome and Celje. The 23 cities would average 2 "premature" lung cancer per 100 000 inhabitants.

In all the 23 cities, all other things being equal, the HIA estimated that 743 "premature" lung-cancer deaths might be prevented annually if long-term exposure to converted $PM_{2.5}$ levels were reduced by 3.5 µg/m^3 in each city.

For each city, the following map shows the long-term health impact on total, cardiopulmonary and lung cancer mortality for a reduction to 20 µg/m^3 in $PM_{2.5}$ levels expressed in number of deaths per 100,000 inhabitants.

Map of long-term impact on total, cardiopulmonary and lung cancer mortality for a reduction to 20 µg/m^3 in $PM_{2.5}$ levels. Number of deaths per 100 000 inhabitants



4. $PM_{2.5}$: Expected gain in life expectancy

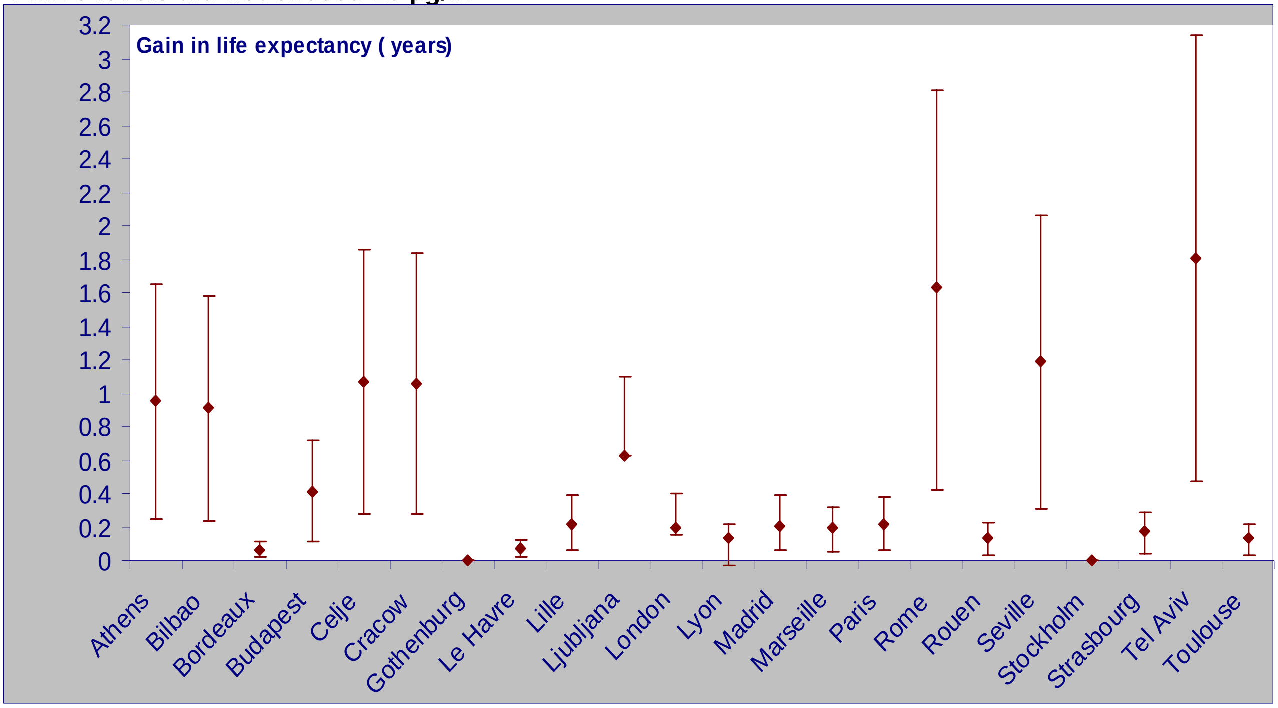
For both total and cause-specific mortality, the benefit of reducing converted $PM_{2.5}$ levels to 15 µg/m^3 is more than 30 % higher than for a reduction to 20 µg/m^3. For this reason, we only presented the calculations in terms of life expectancy for the scenario where converted $PM_{2.5}$ levels would not exceed 15 µg/m^3.

For each city the following table and figure present the findings in terms of expected gain in life expectancy at 30 years of age if the annual mean of converted $PM_{2.5}$ levels did not exceed 15 µg/m^3.

Table 10. Expected gain in life expectancy at 30 years of age if the annual mean of converted $PM_{2.5}$ levels did not exceed 15 µg/m^3

City	Increase in life expectancy at age 30 Mean estimate (years)	Increase in life expectancy Low estimate (years)	Increase in life expectancy High estimate (years)
Athens	1.0	0.3	1.7
Bilbao	0.9	0.2	1.6
Bordeaux	0.1	0.0	0.1
Bucharest	2.3	0.6	3.9
Budapest	0.4	0.1	0.7
Celje	1.1	0.3	1.9
Cracow	1.1	0.3	1.8
Gothenburg	0.0	0.0	0.0
Le Havre	0.1	0.0	0.1
Lille	0.2	0.1	0.4
Ljubljana	0.6	0.2	1.1
London	0.2	0.1	0.4
Lyon	0.1	0.0	0.2
Madrid	0.2	0.1	0.4
Marseille	0.2	0.1	0.3
Paris	0.2	0.1	0.4
Rome	1.6	0.4	2.8
Rouen	0.1	0.0	0.2
Sevilla	1.2	0.3	2.1
Stockholm	0.0	0.0	0.0
Strasbourg	0.2	0.0	0.3
Tel-Aviv	1.8	0.5	3.1
Toulouse	0.1	0.0	0.2

Figure 33. Expected gain in life expectancy at 30 years of age if the annual mean of converted PM2.5 levels did not exceed 15 µg/m³



All other things being equal, if the annual mean of converted $PM_{2.5}$ levels did not exceed 15 µg/m³, the expected gain in expected life expectancy of a 30-year-old person would range on average between 2 and 13 months, due to the reduced risk of death from all causes.

In this scenario, the gain in life expectancy would benefit all 23 cities. However, Tel Aviv, Rome and Seville followed to a lesser degree by Celje, Cracow, Athens, Bilbao and finally, Ljubljana and Budapest would show the greatest benefits. Swedish cities already present levels below 15 µg/m³.

The following figures illustrate for this last scenario the expected gain in life expectancy for successive ages in one city and then show by how much this gain would affect each age.

Figure 34 shows two curves for life expectancy in the city of Seville, taken as an example, for successive age groups:

1) Life expectancy if the annual mean of converted $PM_{2.5}$ remains as it is today in Seville
2) Life expectancy if, all other things being equal, this annual mean did not exceed 15 µg/m³.

Figure 34. Life expectancy for current converted $PM_{2.5}$ levels and reduction to 15 µg/m^3 in Seville.

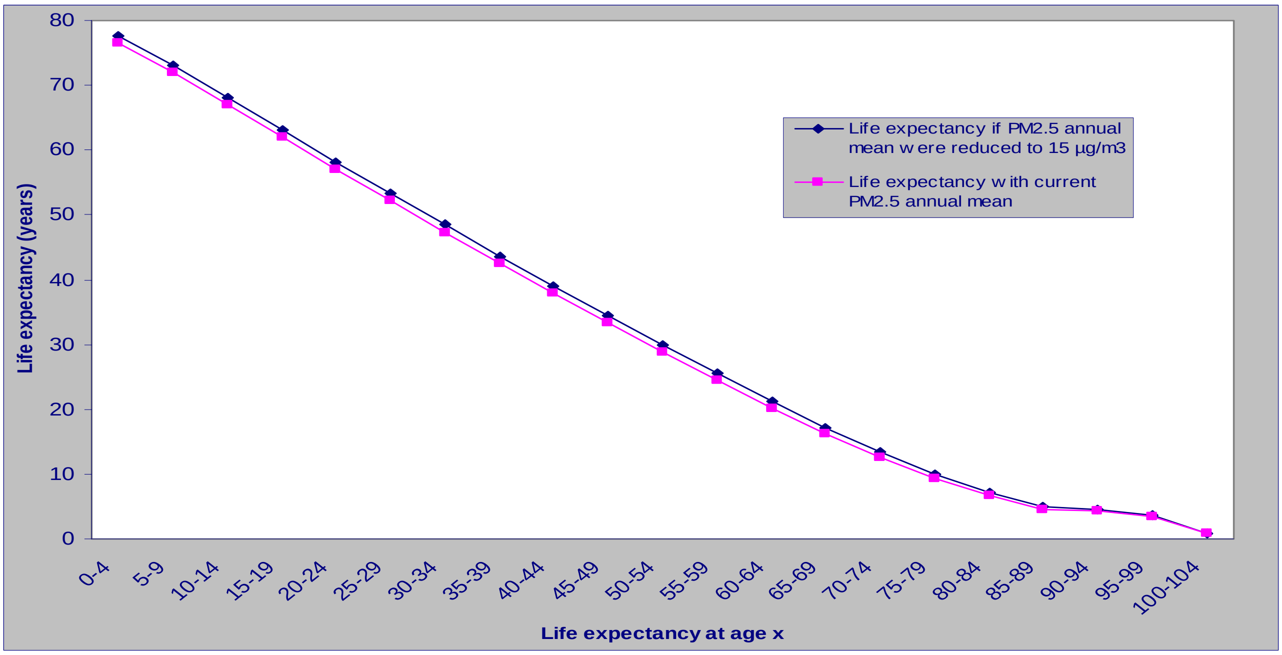
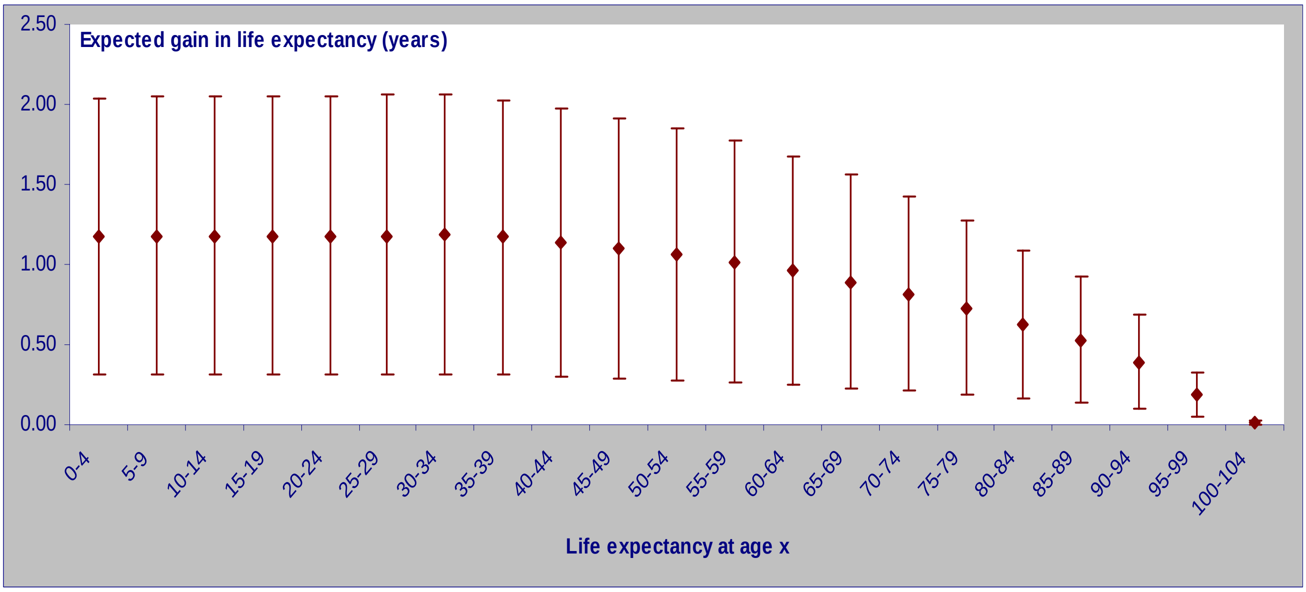


Figure 35 shows in detail the expected gain in life expectancy at each age. If, all other things being equal, the annual mean of converted $PM_{2.}$ levels did not exceed 15 µg/m^3, as seen in Figure 34 above, the gain would remain greater than 1 year until 60 years of age and would then start decreasing.

Figure 35. Expected gain in life expectancy if $PM_{2.5}$ annual mean levels did not exceed 15 µg/m^3 in Seville.



Findings in terms of years of life lost only appear in the city reports.

Interpretation of findings

This section reviews our objectives and discusses how we met them.

Objectives

The HIA part of this mainApheis-3 report has two main objectives:

1. Present a coherent methodology for local HIAs that the individual city-specific reports can use and refer to.
2. Establish a standard basis for comparing findings across cities; and report similarities and differences regarding both the application of methodologies and the HIA findings.

Causality assumption

Our HIA provides the number of health events attributable to air pollution in the target population assuming that air pollution actually *causes* the observed health effects. The scientific basis for this hypothesis has been widely discussed in the literature and in the Apheis-2 scientific report.

A conservative approach

Various HIAs of the effects of air pollution focus on different pollutants and a different range of health endpoints in accordance with the purpose of the HIA.

Some HIAs seek to estimate monetary costs of the impact on health of such factors as a specific source of air pollution, or the monetary benefits of pollution reduction (ExternE 1999, 2001[JFH1]; Kunzli et al. 2000). These studies are intended to provide data for policy in order to compare the costs and benefits of a new development, or of a specific policy to control pollution. For this purpose, since it is important that the HIAs provide the most comprehensive picture possible of the impacts on health and so they use the most complete range possible of outcomes for which a risk estimate is available. Typically, as well as including mortality and hospital admissions, they also include respiratory symptoms, restricted-activity days, development of chronic bronchitis etc., i.e. they include outcomes where fewer studies support the evidence, but where impacts on health would be under-estimated if these outcomes were ignored.

Our HIA, on the other hand, seeks to provide a picture of the overall impact of air pollution on the health of the general population in urban areas in Europe. For this purpose, we chose a conservative, robust and, thus, less exhaustive approach, like the COMEAP study (1998, 2001).

- This enables us to have a strong common basis, well grounded in evidence, for comparing the health effects in different European cities – even if that common basis omits some effects where the evidence is less secure
- It also means that, when results are discussed with policy makers locally, the scientific basis for the effects quantified is very strong.

In terms of practical implications, this strategy has some important consequences.

First, we only used exposure-response functions (E-R functions) or risk estimates that are well established.

Second, regarding the health outcomes described as associated with air pollution, we only included total and cause-specific mortality for both this general report and the city-specific reports, and hospital admissions only in city-specific reports. We did not consider many other health outcomes potentially relevant for an HIA as proposed by WHO (WHO 2001).

Third, we did not consider vulnerable subgroups of the population as defined by age or history of diseases (WHO, 2004).

And finally, regarding the air pollutants that could be considered, we limited our analysis to particulate pollution as a surrogate for the complex air-pollution mixture. There is a case for also evaluating an independent effect of ozone, but the particulate effects are the dominant ones.

We used three particulate indicators in order to provide a range of possible impacts of air pollution on health using different exposure-response functions, different cities and different age-groups. It should be noted that it is of crucial importance that HIA findings shown for different scenarios and different particulate indicators not be added together. This is because the pollutants are highly correlated, some of the impacts provided by one indicator may already be included in another indicator, and some of the impacts provided in one scenario are already included in another scenario.

Threshold considerations

Because the E-R functions we used in this HIA are linear, we did not assume any threshold in our calculations. While individuals may have different thresholds regarding their sensitivity to air pollution, this linear relationship means that for the general population there is no threshold below which air pollution has no impact on health (Schwartz et al 2000, Daniels et al 2000). This viewpoint is especially well recognised with regard to particulate pollution (WHO, 2004). In particular, analyses of the effects on mortality of long-term exposure to $PM_{2.5}$ give no indication of a threshold of effects.

Instead of choosing a single reference level, our HIA proposes a range of reference levels of particulate pollution used in different scenarios.

Other methodological considerations

HIAs only provide estimates of the true health impacts, and our HIA, like other HIAs, estimates the number of events (deaths or hospital admissions) that can be attributed to exposure to particulate air-pollution in a specific city. We have expressed these numbers both in absolute terms directly related to the size of the population studied, and as rates per 100 00 inhabitants to allow comparisons between cities.

To gain a better sense of the overall uncertainty of these estimates, we followed WHO recommendations (WHO 2000, 2001) and we conducted sensitivity analyses as part of our exploration of important HIA methodological issues.

In the following pages we will describe these methodological considerations for:
- Exposure assessment
- Health outcomes and baseline or background rates
- Exposure-response functions
- Statistical tools

Exposure assessment

Regarding exposure data, our HIA findings depend directly on the levels of particulate pollution measured. These levels vary widely as a function of the number and location of the monitoring sites, the analytical methods used, and the sites selected for our HIA. This explains the importance of using the Apheis guidelines to ensure comparability of the data.

As described in Appendix 3 on exposure assessment, the exposure measurements used in Apheis-3 were compared to and interpreted using of the Apheis Guidelines on Exposure Assessment.

Measurement intervals for air quality indicators

Because the E-R functions selected for HIA of short-term exposure use the 24-hr average measurement interval, 24-hr averages for PM_{10}, $PM_{2.5}$ and BS were recommended by the Apheis guidelines, and the Apheis cities complied with the given recommendations for all monitoring stations. For HIAs of long-term exposure, E-R functions selected used annual levels, and so did the Apheis cities.

Number of stations and site selection

Altogether 142 monitoring stations were selected for HIAs in accordance with the Apheis site selection criteria. In a few cities, only one or two stations were used but they were background stations and thus provide a partial view of the population exposure. In three cities, 28 stations were classified as directly traffic-related and theoretically should be excluded for HIA calculations. Despite this, the data from these stations was used for HIA because: 1) local experts considered they were representative of the population's exposure in those cities; 2) E-R functions used for HIAs of short-term exposure used these direct traffic-related stations, although not the studies selected for HIAs of long-term exposure.

Measurement methods

The PM_{10}/$PM_{2.5}$/BS/TSP measurement methods were reported completely. Automatic PM_{10} measurement methods (the ß-ray absorption method and the tapered oscillating microbalance method (TEOM)) were used. $PM_{2.5}$ measurements were done only by TEOM. Reflectometry is the method commonly used to measure BS. TSP was measured by the ß-ray absorption method in one city and by gravimetric method in the other.

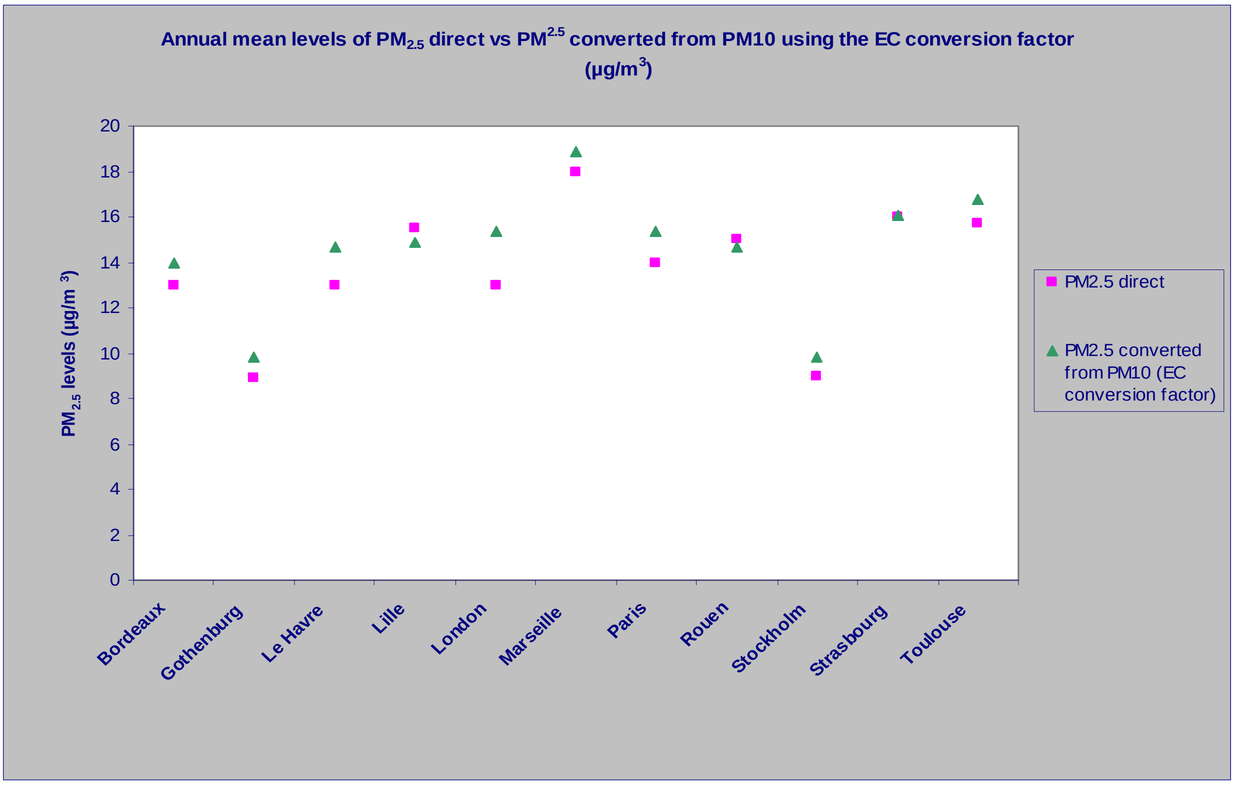
Correction factors

None of the cities used the European PM_{10} reference method (gravimetric method) for their PM measurements. As a reminder, for long-term HIAs of PM_{10} and $PM_{2.5}$, because the E-R functions used were taken from the ACS study that used gravimetric methods, to be consistent we had to correct the automatic PM_{10} measurements by a specific correction factor (local or, by default, European) in order to compensate for losses of volatile particulate matter. Cities where the information was available could use local correction factors. In actual fact, after consulting the reference laboratory in France, the French cities decided to use two correction factors based on comparative local measurements using gravimetric and TEOM methods: one for summer (moderate levels of PM: 1-1.18) and one for winter (increased levels of PM: 1.2-1.37). In general, local conversion factors were slightly lower than the European factor of 1.3 recommended by the EC Working Group on Particulate Matter:

Conversion factors

Besides this correction factor, conversion factors (local or European) were given for calculating PM_{10} from TSP measurements, as well as for $PM_{2.5}$ data calculated from PM_{10} measurements. As a reminder, the default factor of 0.7 for $PM_{2.5}$ was recommended by the Apheis Exposure Assessment Working Group as a mean value based on two different recent publications. First, as part of the process of revising and updating the so-called 1st European Daughter Directive, the 2nd Position Paper on Particulate Matter (draft of 20 August 2003, available for the PM Meeting in Stockholm) presents the results from 72 European locations reported by several Member states from 2001. It gives $PM_{2.5}/PM_{10} = 0.65$ (range 0.42-0.82, se = 0.09). Second, Van Dingeren et al. (2004) recently published a European research activity, with a smaller number of stations (11 stations), giving the ratio = 0.73, se = 0.15 (range 0.57-0.85).

Figure 35 presents, for Apheis cities that could compare both, the annual mean levels of $PM_{2.5}$ directly measured and $PM_{2.5}$ converted from PM_{10} calculated using the European conversion factor (0.7). As we can see, except in Lille, Rouen and Strasbourg, the annual mean of $PM_{2.5}$ measured directly is lower than the annual mean levels of $PM_{2.5}$ converted from PM_{10} calculated using the European conversion factor. It could imply that the European conversion factor is a little too high. In fact, the average local conversion factor is 0.66, very close to the one proposed by the 2nd Position Paper on Particulate Matter (2003).



Estimates of corrected PM_{10} and converted $PM_{2.5}$ for HIAs of long-term exposure may thus be high. We could conclude that, if there were no other uncertainties elsewhere, mortality estimates related to long-term exposure to PM_{10} and $PM_{2.5}$ could consequently be higher too. But there are many other sources of uncertainties that may contribute to under (or over) estimate the impact: transferability of E-R functions, number of air-pollution and health indicators considered for HIA, including or not including sensitive sub-groups of the population, and other sources of uncertainties that are described in this section.

Quality assurance and control (QA/QC), and data quality (DQ)

Most cities reported that QA/QC activities were implemented. All cities reported that the DQ could be assessed and validated.

We concluded that, overall, the assessment of exposure data in Apheis-3 was sufficiently reliable for our HIA purposes.

Health outcomes and baseline rates

Regarding health outcomes, Appendix 6 describes the data provided in detail.

Mortality data

The information sources for mortality data were the national, regional or local mortality registries for all the cities. Mortality rates were the highest in eastern cities in Europe.

In Apheis-3, cause-specific mortality was included besides all-causes mortality as complementary information to enrich the mortality picture. But all-causes mortality remains our first choice because it is more robust, not subject to misclassification and easier to obtain. In addition to the number of cases, life-expectancy calculations were made using total mortality in people of 30 years of age.

Given that most of the cities applied a quality-control programme and given the low percentage of missing data for all-causes mortality, we consider that erroneous entries in the selection of cause of death did not affect the comparability of the data between cities.

Hospital admissions data

To estimate the acute effects on hospital admissions of short-term exposure to air pollution, we have selected hospital admissions for residents of each city with discharge diagnoses of respiratory diseases (ICD9: 460-519; ICD10: J00-J99) and cardiac diseases (ICD9: 390-429; ICD10: I00-I52). Whenever possible we only used emergency admissions as being more specifically related to air pollution, and we used discharge diagnoses for all-cases because they are more reliable.

All the cities obtained the data from registries. The completeness of the registries on hospital admissions was quite high, being 95% or more in 18 of the 22 cities. We didn't know this percentage in two cities (London and Tel Aviv). Barcelona and Valencia had a slightly lower level of completeness. In Apheis-2, French cities (Bordeaux, Lyon, Le Havre, Lille, Marseille, Paris, Rouen, Strasbourg and Toulouse) only included public hospital admissions, while the completeness has been 100% in most of these cities in Apheis-3.

All the registries run a quality-control programme, and completeness of the diagnosis of the cause of admission was quite high, with a percentage of missing data of 1% or lower in 19 of the 22 registries. We didn't know this percentage in three cities (London, Tel Aviv and Valencia).

For cities with emergency admissions, respiratory admissions cluster closely. Cardiac admissions show greater variability, but the extreme difference (Stockholm against Valencia) shows a factor of more than two. In the literature, within western Europe a north-south gradient is described for cardiovascular diseases and even more striking for ischaemic heart disease, with some "reverse" inequalities in southern Europe (Mackenbach et al, 2001).

The main problem for comparability remains the difference in the availability of information in the registries, because some cities used emergency admissions, while others that lacked this information used total admissions. The information sources used in Barcelona, Bilbao, Budapest, Gothenburg, London, Madrid, Seville, Stockholm and Valencia allowed selecting emergency admissions. Yet for Bordeaux, Celje, Le Havre, Lille, Ljubljana, Lyon, Marseille, Paris, Rome, Rouen, Strasbourg, Tel Aviv and Toulouse, it was not possible to distinguish between emergency and total admissions.

Methodologically speaking, statistical analyses of the APHEA-2 cities showed no significant heterogeneity in the estimated RR of hospital admissions between cities that reported general hospital admissions and those that reported emergency hospital admissions only (Atkinson 2001, Le Tertre 2002). This might seem surprising initially but in fact is very reasonable. General admissions include both planned and emergency admissions, and when controlling for season we also control for general trends for both, leaving emergency admissions and some background noise.

This does raise an important issue for HIA if general admissions are used rather than emergency ones and if the same RR is applied. We should investigate the possibility of using a correction factor from emergency admissions and apply it to general admissions. There is a need to examine this and other approaches to determine how best to handle the difficult situation of HIAs when baseline data are unknown, or missing, or collected using different conventions.

The analysis of health data quality and availability concludes that, for local use in each city, the selected data was reliable. When comparing findings between cities, the data is fully comparable for the selected categories of mortality. Nevertheless, even if most of the cities have hospital data from registries that use a quality-control programme, such comparability was limited for the incidence of hospital admissions, because some cities used emergency admissions while others used total admissions, and the incidence rates from these two types of admissions (Figure 5) do not appear to be fully comparable. Consequently, we only present data for hospital admissions and the consequent HIAs in the city-specific reports, and our study still stresses the need to promote the use of more-uniform hospital admissions data in Europe.

Choosing the exposure-response functions

HIAs of short-term exposure

Two HIAs of short-term exposure

For the first time in Apheis, we conducted two HIAs of short-term exposure using two types of exposure-response functions: for a very short-term exposure (usually 1 or 2 days) and for a cumulative exposure (up to 40 days). Our objective was to better understand the effects of particulate pollution on health over time for short-term exposures.

For the very short-term exposure, we used a new exposure-response function developed by Apheis-3 for all-ages respiratory admissions (Appendix 2). We also used exposure-response functions newly developed by WHO from a meta-analysis of time series and panel studies of particulate matter (PM) **http://www.euro.who.int/document/E82792.pdf**

For the cumulative short-term exposure (up to 40 days), in Apheis-3 we also used Zanobetti's (2002, 2003) estimates using distributed-lag models that showed the cumulative effect was more than twice that found using only 2 days of follow-up.

HIA of short-term exposure on respiratory admissions for all ages

In Apheis-2 the HIA was performed for respiratory admissions > 65 years because it is well-known that acquired susceptibility from chronic diseases increases with age (WHO 2004). Nevertheless, below 65 years air pollution also has an impact on health. We then decided to study the impact of particulate pollution on respiratory admissions for all ages. Because in the literature there was no E-R function for all-ages respiratory admissions, it was decided in Apheis-3 to provide this new E-R function (see Appendix 4) and calculate the consequent health impact.

Transferability of E-R functions for short-term exposure

The question of transferability of E-R functions is not a matter of concern for short-term exposure since most of the Apheis cities are some of the cities where the E-R functions were estimated.

Sensitivity analysis using different types of estimates

As stated briefly in the "Methods" section, most HIAs, including Apheis HIAs, use overall estimates from multi-centre studies. But in some cases, people doing an HIA in a particular city where an epidemiological study has been conducted providing local E-R functions prefer to use city-specific estimates. The Apheis statistical advisory group conducted a sensitivity analysis in some cities to address this issue, using different effect estimates (observed city-specific, shrunken city-specific, pooled, mean of shrunken city-specific and adjusted for effect modifiers) to calculate the number of "premature" deaths in each city.

The study concluded that, although the sum for 21 European cities of the deaths attributable to PM_{10} is not strongly influenced by the method used to estimate RRs, this is not true at the city level. Applied to a single city, the different estimates tested present benefits and limits, and based on these limitations the authors recommend using the shrunken estimate in cities for which this option is available. This shrunken estimate has the property to derive the overall estimate at the local level by combining information from the city-specific estimate and the overall one and can be considered as a weighted mean between these two estimates. The shrunken estimate also reduces the variability of the local estimate by incorporating information from other cities. The shrunken-estimates approach has already been explored and applied to air pollution (Post et al, 2001). A key disadvantage of such an estimate is that it can only be applied in cities that formed part of the initial analysis. The use of this type of estimate will be proposed at the city level in the next Apheis HIA. A full description of this analysis appears in Appendix 5.

HIAs of long-term exposure

In Apheis-3, long-term HIAs were conducted in terms of number of "premature" deaths for PM_{10} and $PM_{2.5}$ and in terms of expected gain in life expectancy for $PM_{2.5.}$

- For long-term exposure to particulate pollution, European E-R functions were still not available at the time the study was conducted.

Transferability of E-R functions for long-term exposure

In Apheis-3, for $PM_{2.5}$, we used an update of the ACS study (Pope, 2002) covering 1.2 million adults in 50 states that doubled the follow-up time to more than 16 years, controlled for more confounding factors and used recent advances in statistical modelling. This study's findings confirm the associations observed in their previous study, which we used for PM_{10}. But the question of transferability of estimates between the U.S. and Europe raises uncertainties, since the particulate mixtures and populations can differ between the two continents.

Also relevant for transferability are differences in methods used in the U.S. and Europe for exposure measurement, e.g., $PM_{2.5}$ gravimetric vs automatic methods. We used a correction factor for PM_{10} observed values to compensate for losses of volatile particulate matter. But, on the other hand, the application of this correction factor may be another source of uncertainty in our HIAs.

We should also be cautious if the E-R functions used were extrapolated to a city with particulate levels beyond the range of the original study. This also applies for HIAs of short-term exposure. On the other hand, the general linearity of the E-R functions within the ranges studied gives some reassurance that extrapolation beyond these ranges should not be seriously misleading.

The question of transferability is unlikely to be a concern for the health outcomes we used, since they are limited to total and very broad cause-specific mortality.

Statistical tools

Short-term and long-term number of cases

For our HIA's statistical method, we used WHO guidelines (WHO 2001) as a starting point and also developed our own standardised statistical and HIA guidelines (Medina et al. 2001).

Calculations for short- and long-term number of cases were conducted using an Excel spreadsheet (Appendix 7) developed by the French surveillance system on air pollution and health, PSAS9 (Le Tertre et al. 2002).

When building our own E-R functions on respiratory admissions for all ages, we used the APHEA 2 methodology (Katsouyanni et al 2001) taking into account the problems with GAM raised by NMMAPS (Dominicci 2002) and investigating the sensitivities of the estimated pollution effects by using alternative smoothing techniques, parametric and non-parametric, and by using a range of smoothing parameters. These analyses are described in detail in Appendix 4.

Gain in life expectancy and years of life lost

For the first time in Apheis, we calculated the gain in life expectancy and years of life lost (YoLL). For this purpose we used the WHO-ECEH AirQ 2. 2. 2. software based on the methods summarized by Miller BG in WHO, 2001.

As explained in the "Methods" section, life expectancy calculations are based on the following considerations: the survival curve for a birth cohort predicts the temporal pattern of deaths in the cohort. Expected life from birth can be calculated by summing the life years over all period and dividing by the size of the starting population. Conditional expectation of life, given achieving a certain age, can also be calculated by summing the years of life at that age and later, and dividing by the number achieving that age (Miller BG in WHO, 2001).

Life expectancy with zero mortality for one cause can be used to indicate the relative importance of an illness. A life table is calculated assuming the complete elimination of a particular cause, and the resulting hypothetical life expectancy is compared with the actual life expectancy (Romeder and McWhinnie, 1977). The greater the difference, the greater is the relative importance of the cause. In air-pollution HIAs, a similar approach can be used, and actual life expectancy can be compared with the hypothetical life expectancy obtained for the baseline scenario. For that purpose, hazard rates must be predicted in the baseline scenario. In Apheis we assumed the same proportional hazard reduction for every age-group, and calculated hazard rates of the baseline scenario by dividing the actual hazard rates by the corresponding relative risk.

In general, our HIA aimed at providing an average effect for the whole population because, as stated by Künzli, (2000), a relatively minor deterioration in the average of the outcome for the whole population may reflect an important shift in the proportion of seriously affected individuals within a population. Indeed, our HIA did not focus on sensitive subgroups defined by their history of disease or their age. However, as an example of the potential gain in life expectancy if $PM_{2.5}$ levels were reduced, calculations were made for an adult of 30 years.

Years of life lost calculations were also conducted using AirQ. However, since YoLL calculations express the same kind of information as gain in life expectancy, it was decided not to include them in this main report. Instead they appear in each city report for total and cause-specific mortality.

Conclusions and recommendations

What's more important: Long-term or short-term? Number of deaths or gain in life expectancy?

Long-term vs. short-term

When interpreting the findings on annual mortality, we should remember that the main effects of air pollution are associated with long-term exposure. Most of the acute effects on mortality are included in effects of long-term exposure and represent around 15% of these chronic effects, when judged in terms of the number of attributable cases. But not all short-term health impacts are included in the long-term impacts (Medina et al in press, Kunzli et al. 2001). It was interesting to note that the cumulative short-term impact over up to 40 days was more than twice that found using only 2 days of exposure follow-up (Zanobetti et al. 2002), showing that air pollution does not simply displace mortality by a few days. Consequently, omitting E-R functions from time series would lead to under-estimating the short-term impact on mortality.

Number of deaths vs. gain in life expectancy

Attributable cases are often interpreted as the preventable fraction, meaning those that would have been prevented had exposure been removed. However, caution should be used with such an interpretation. First, the benefit of removing a particular exposure can only rarely be estimated. The benefit may be achieved much later than predicted, or not to the full extent predicted. In our case, lower air pollution levels would take years to be fully achieved. Second, the attributable risk estimation does not take competing risks into account. Removing one risk factor, e.g., air pollution, will increase the relative importance and contribution of other risks and causes of morbidity and mortality. Accordingly, for multicausal diseases it is well known that the sum of attributable cases across several risk factors does not add up to 100% but may be larger. Nevertheless, recent intervention studies (Heinrich et al. 2002, Hedley et al. 2002, Clancy et al. 2002, Friedman et al. 2001) do indicate the reduction in mortality and morbidity after decreases in air pollution.

For the time being, expressing mortality findings in terms of "premature" deaths per year is an easy-to-understand way of communicating health/mortality impacts. It gives a picture at one point in time. Another way of expressing mortality findings is in terms of expected gain in life expectancy, which provides a more dynamic picture.

The magnitude of the problem

What is the contribution of particulate pollution to the total burden of mortality in the Apheis cities? One way of assessing the magnitude of the problem is to calculate within the total number of deaths observed and reported by each city the percentage of “premature” deaths attributable to reducing PM levels to 20 µg/m^3.

In our HIA for PM_{10}, exposure has focused on very short-term, cumulative short-term (raw PM_{10} levels) and long-term effects (corrected PM_{10} levels). All other things being equal, when only considering very short-term exposure, the proportion of all-causes mortality attributable to a reduction to 20 µg/m^3 in raw PM_{10} levels would be 0.9% of the total burden of mortality in the cities measuring PM_{10}. This proportion would be greater for a cumulative short-term exposure up to 40 days (1.8%). For long-term exposure to corrected PM_{10} levels, it would be 7.2%.

For BS, only very short-term exposure (raw levels) was considered. All other things being equal, the proportion of all-causes mortality attributable to a reduction to 20 µg/m^3 in BS levels would be 0.7% of the total burden of mortality.

Lastly, for long-term exposure to $PM_{2.5}$ converted from corrected PM_{10}, all other things being equal, the proportion of all-causes mortality attributable to a reduction to 20 µg/m^3 in converted $PM_{2.5}$ levels would be 4% of the total burden of mortality.

As we can see, the contribution to the total burden of mortality of short-term, cumulative short-term and long-term exposure to particulate air pollution is not negligible. Public health will be better served if we recognise not only that air pollution exposure is hazardous, but also determine the magnitude of this hazard.

Implications for policy making: air pollution indicators and limit values

PM vs. BS

There is substantial toxicological and epidemiological evidence of the effects of PM on mortality and morbidity. And it has been highlighted that primary, combustion-derived particles have the highest toxicity (WHO 2004). PM_{10} , BS and $PM_{2.5}$ are important indicators of PM, and respective HIA findings show that the estimated impacts are significant. However, because these three pollutant indicators are highly correlated, HIA findings must not be added together.

PM_{10} levels are already regulated by the European Commission, and the Position Paper on Particulate Matter, prepared for the CAFE programme, postulates using $PM_{2.5}$ as a principal metric to assess PM exposure. Unfortunately, black smoke regulation has ceased, and no European Directive is planned for BS by 2005 or by 2010. Nevertheless, this air-pollution indicator, which has been measured for many years in most European cities, represents small black particles (less than 4 µm in size) with measurable health effects and may be considered as a good proxy for traffic-related air pollution closely related to diesel engine exhaust in urban areas (WHO 2003).

Given the evidence currently available, policymakers should consider the air-pollution mixture as a whole for setting standards, and not favour some air-pollutant indicators over others.

PM_{10}: Meeting 2005 and 2010 European limit values

The year 2005 is almost here, and European the annual limit value of 40 µg/m^3 for PM_{10} is still exceeded in a few Apheis cities in southern and eastern Europe, although 18 of the 23 cities that measured PM_{10} already meet the annual cut-off of 40 µg/m^3. However, excepting the two Swedish cities, the 2010 annual limit value of 20 µg/m^3 for PM_{10} is exceeded in most Apheis cities, although London and 8 of the 9 French cities show levels close to 20 µg/m^3. Incentives to reduce PM_{10} levels in the short and medium terms are needed to help further reduce air-pollution levels. A coordinated initiative by European legislators and national and local policy-makers could help achieve this goal.

$PM_{2.5}$: 20 or 15 µg/m^3 for the European limit values?

Our HIA provides new evidence for the ongoing discussions that will set limit values for $PM_{2.5}$ as part of the CAFE legislation process for the European Commission (http://europa.eu.int/comm/environment/air/café/index.htm). In Apheis-3, for both total and cause-specific mortality, the benefit of reducing $PM_{2.5}$ levels to 15 µg/m^3 is more than 30% greater than for a reduction to 20 µg/m^3. Thus, for public-health reasons, our HIA recommends 15 µg/m^3 as the limit value for $PM_{2.5}$. However, because a significant health impact will be expected even at 15 µg/m^3, further reductions in pollution are advised.

Implications for communicating Apheis' findings better to policy makers

As a reminder, the Apheis programme seeks to meet the information needs of individuals and organizations concerned with the impact of air pollution on health in Europe; and most importantly the needs of those individuals who influence and set policy in this area on the European, national, regional and local levels.

Doubts about the ability of Apheis' scientific reports alone to meet the needs of this key audience led us to develop a communications strategy based on learning this audience's needs directly from its members.

Our research showed in particular that:

- Policy advisors and makers are generally unlikely to use the scientific reports we develop as is, contrary to scientists

- Policy advisors and makers comprise scientific and policy users and each of these groups has different problems to solve, different ways of processing information, different levels of scientific knowledge and different cultures, meaning each group has different information needs
- A long, complex chain comprising many players leads from the scientists to whom we distribute our reports directly, and who use them, to the policy makers who ultimately have the greatest effect on public health, but who only receive our reports indirectly and use them rarely, if at all.

Based on this evidence, we concluded that Apheis needs to act proactively to:

- Apply the above knowledge to the way it shapes and delivers its information and messages
- Develop a range of communications tools that goes beyond our comprehensive scientific reports to include summary reports, brochures, presentations and Q&As whose focus, content and form are tailored to the separate information needs of scientific and policy users
- Ensure that the information needed by policy advisors and makers actually reaches them.

Taking these steps will greatly enhance the way Apheis communicates with the key audiences that set policy on air pollution in Europe, and will thus help Apheis contribute better to improving public health.

Conclusion

Apheis-3 established a good basis for comparing methods and findings between cities, and explored important HIA methodological issues.

To provide a conservative overall picture of the impact of urban air pollution on public health in Europe, like its predecessor Apheis-2 the Apheis-3 project used a limited number of air pollutants and health outcomes for its HIAs.

Apheis-3 added more evidence to the finding in Apheis-2 that air pollution continues to pose a significant threat to public health in urban areas in Europe. And it added further support to WHO’s view that “it is reasonable to assume that a reduction of air pollution will lead to considerable health benefits.” And, at least for particulate pollution, our findings support WHO’s already strong recommendation for “further policy action to reduce levels of air pollutants including PM, NO2 and ozone” (WHO 2004).

Future steps

The Apheis communications strategy will be implemented when funds are allocated to developing the different communications tools recommended for each of our target audiences.

While continuing the development of HIAs of outdoor air pollution, Apheis will join the ENHIS project (Environment and Health Information System) of the WHO-European Centre for Environmental Health (ECEH) co-sponsored by the European Commission and ENHIS's partners.

In this new project, Apheis will coordinate health impact assessment issues; it will test and adapt, in new cities and for new environmental risk factors, the methodology developed by Apheis; and Apheis will establish interactions with other kinds of impact assessments. The ultimate goal of this new phase of Apheis' work is to provide a global picture of the environmental burden of disease in Europe.

Special thanks

Last but not least, the huge amount of work behind these pages is the fruit of the generous and constructive input from all the members of the Apheis network. We wish to extend our special thanks and appreciation to all of them.

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