APHEIS

Air Pollution and Health: a European Information System

Monitoring the Effects of Air Pollution on Health in Europe

Scientific report 1999-2000

DG SANCO G/2
"Pollution-related diseases" programme

Ajuntament de Barcelona
Institut Municipal de Salut Pública

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APHEIS cities

APHEIS cities:

- Greece: Athens.
- Ireland: Dublin.
- Poland: Cracow.
- Romania: Bucharest.
- Hungary: Budapest.
- Republic of Slovenia: Ljubljana, Celje/Koper.
- France: Bordeaux, Le Havre, Lille, Lyon, Marseille, Paris, Strasbourg, Toulouse, Rouen.
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INTRODUCTION

Air pollution continues to threaten public health in Europe, despite tighter emission standards, closer monitoring of air-pollution levels and decreasing levels of certain types of air pollutants.

Many research studies have sought to quantify the effects of air pollution on health. In Europe, the APHEA project[1-15] (Short-term Effects of Air Pollution on Health: A European Approach Using Epidemiological Time Series Data) is one of the most relevant studies that evaluates the relationship between short-term changes in levels of air pollution and health. Using a standardised protocol, APHEA was able to combine observed local estimates of the effects of pollution on health in a meta-analytical approach that provides global, robust short-term estimates.

Air pollution has also a long-term, detrimental impact on health. It increases occurrences of deaths, asthma attacks, bronchitis, heart attacks and other pulmonary and cardiovascular diseases; and it impairs the development of children's pulmonary capacity[16-30].

Animal and experimental studies also confirm the negative effects of air pollution on health. The oxidant properties of PM_{10} have been demonstrated in the lung[31]. In normal animal models, PM_{10} have produced lung inflammation with local evidence of oxidative stress[32]. McNee et al[33] have developed a plausible hypothesis for the systemic effects of PM_{10}. Experimental and clinical studies[34-41] have also confirmed the role of oxidative stress in cardiovascular diseases.

Complementary to research efforts, health impact assessment (HIA) is today being used more and more frequently on a routine basis for decision making and evaluating the economic consequences of the impact of air pollution on health[42-45].

The key value of APHEIS lies in serving as a bridge between the learnings of research and their application to the management of air quality and the implementation of public-health actions on local, national and European levels. In specific, APHEIS aims to provide decision makers, environmental-health professionals and, indeed, the general European public with a comprehensive, up-to-date and easy-to-use information resource on the impact of air pollution on public health. This will help them make more-informed decisions about the political, professional and personal issues they face in this area.

During its first year (1999-2000), APHEIS achieved two objectives: a) It defined the most-appropriate indicators for epidemiological surveillance and health impact assessment of air pollution in Europe; b) It identified those institutions best able to implement the epidemiological-surveillance system in the participating centres of the 12 countries involved in the programme.

To meet APHEIS' first objective, the InVS (French National Institute for Public Health Surveillance) coordinated five advisory groups that drafted guidelines to develop a standardised protocol for data collection and analysis in the fields of air-pollution exposure assessment (Exposure AG), epidemiology (Epi AG), statistics (Stats AG) and health impact assessment (HIA AG). The public health (PH AG) advisory group defined the general framework of the surveillance system. The advisory groups included experts in each of the respective fields and representatives from participating cities.

To meet APHEIS' second objective, two specific questionnaires were designed by the research team of the IMSPB and sent to each centre to assess the feasibility of implementing the surveillance system by the participating centres. The information requested was collected by each coordinating centre, then processed and analysed by the IMSPB team.

The process included two steps. The first step, which is the local set-up description, covered aspects relating to local set-up conditions considered important to implement an information system on air pollution and health. The second step, which is the compliance with guidelines, dealt with each participating centre's compliance with the criteria formulated in each of the five specific areas of the guidelines.

The following report presents in order the guidelines developed by the advisory groups followed by the results of the questionnaires. The report concludes with a summary of recommendations for the implementation of the programme and outlines future steps.

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Part I – Guidelines for the feasibility of an epidemiological surveillance system

PUBLIC HEALTH GUIDELINES

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PUBLIC HEALTH GUIDELINES

1.1. Introduction

Public Health Surveillance (PHS) is an ongoing and systematic collection, analysis, interpretation and dissemination of epidemiological information in the process of describing and monitoring a health event related to a risk factor. This information is used by decision-makers for planning, implementing, and evaluating public health interventions and programmes[1,2,3]. Surveillance data are used both to establish the need for public health action and to assess the effectiveness of programs[4].

In the environmental field, PHS has some constraints due to the fact that, most of the time, there are no specific outcomes and no specific exposure indicators. Applied to air pollution, this means that we have to monitor the exposure-response relationships.

APHEIS aims to create an epidemiological surveillance system of the effects of air pollution on health. For the description of the surveillance system, we propose an adaptation of the "Guidelines for Evaluating Surveillance Systems"[1] of the Centres for Disease Control, some guidelines not being applicable to the surveillance of the effects of air pollution on health.

1.2. Public health importance and background

The first statement which has to be reminded is that everyone is exposed to air pollution, and, if at the individual level, health risks related to air pollution may be considered relatively low, their public health impact may be large[5]. The sources, nature and distribution of outdoor air pollution in Europe have changed markedly since the 1950's. There has been a decrease in emissions of particles and sulphur dioxide (SO_2) from the burning of coal for domestic and industrial purposes together with an increase in emissions of oxides of nitrogen and particles from motor vehicles. These changes have occurred at different rates in different areas of Europe. Whereas air pollution used to be largely confined to urban areas, it is now found in suburban and rural areas. This applies especially to photochemical oxidants such as ozone which may be created some distance from the source of precursors, but also to small particles and sulphur dioxide (SO_2) (where it is emitted from high level stacks). The occurrence of air pollution episodes in the past is well known but in certain weather conditions, air pollution episodes (defined as increases above guideline levels) may still occur both in summer (ozone, nitrogen dioxide) and in winter (particles, nitrogen dioxide, sulphur dioxide).

Over the last decade, evidence has been accumulated which suggests that short-term variations in air pollution (i.e. on a day-to-day basis) are associated with measurable effects on mortality and morbidity. Most of this evidence was until recently from North America[6-26], and was accompanied by some scepticism as to whether such low levels of pollution could be plausibly associated with adverse health effects[27-36]. Little work had been done in Europe since the era of major smog events[37-49] and there was a clear need to investigate whether levels of air pollution currently encountered in Europe were associated with adverse health effects.

The APHEA project addressed this question by means of a collaborative project involving 15 cities in 10 countries spanning the range of geographical, climatic and pollution features found across Europe. The method was to use available health and pollution data to examine temporal associations between the two. Details of the standardised protocol[50, 51] and results[52-62] may be found elsewhere. All the measured pollutants (particles, SO_2, NO_2 and ozone) were found to have significant short-term effects in one or more cities. Having clearly established that air pollution is a possible public health hazard, more research has been undertaken under the APHEA2 project to describe exposure-response relationships and investigate interactions between pollutants.

Health impact assessment (HIA) needs these epidemiological findings to extrapolate results of research to populations not covered by detailed studies. The APHEA project used existing data in

cities where there was already public health and academic interest in the health effects of air pollution but this is a fragile basis for solid monitoring in HIA.

Some reasons for developing APHEIS are:

– The confirmation by APHEA and other studies that current levels of pollution are affecting public health;

– The increased public concern on the health effects of air pollution and demands for improved health protection policies;

– The need for further information on which to base regulatory policies and abatement measures; and

– The need to monitor the effects of future changes in the nature and scale of air pollution.

Starting in 1991, in France, the value of creating a pubic health surveillance system was investigated. The ERPURS programme has been monitoring the effects of air pollution on health in the Paris metropolitan area since 1994[63-66]. The later nine-cities PSAS-9[67] programme met the requirements of new French legislation that called for "monitoring air pollution... and its effects on health." Based on these two projects, and on the experience acquired within the APHEA project, the InVS, the French Institute of Public Health, collaborated with Barcelona's Municipal Institute of Public Health to develop and propose the APHEIS programme.

Different from APHEA, APHEIS will create a public health surveillance system that, on a routine basis, will provide an analysis of the effects of air pollution on health tailored to the needs of European decision makers, researchers and citizens.

1.3. System description

1.3.1. Objectives

The main objectives of the APHEIS surveillance programme are:

– To quantify the impact of air pollution on health;

– To monitor on an ongoing basis the changes in health risks related to air pollution in Europe by monitoring the trends in the exposure-response relationships between air pollution indicators and health outcomes;

– To assess the factors associated with changes in trends in the exposure-response relationships

– To provide clear information to decision-makers and to citizens concerning the impact of air pollution on their health

In particular, APHEIS will continue to analyse the short-term effects of air pollution on health in Europe and update the findings in the coming years.

1.3.2. Events under surveillance

As we already said, the difficulty in epidemiological surveillance of air pollution is that there are no specific outcomes regarding air pollution effects. Generally, we look at respiratory and cardiovascular diseases in terms of mortality and some subcategories like asthma attacks, chronic obstructive pulmonary diseases and myocardial infarction for hospital admissions.

Exposure to air pollution is measured at fixed monitoring sites. The assumption is that people living in the study area are exposed on average to the same levels of air pollution.

1.3.3. Components and operation of the surveillance system

The components and operation of the surveillance system will be described in detail in the following guidelines and in the second part of this report but here we give some general considerations.

a. *Which population is under surveillance?* All the residents of the defined study area covered by the local air pollution monitoring network in each city.

b. *What is the information to be collected?* Detailed description about the information to be collected, the time frame and the criteria of quality should be made available by the Exposure, Epi and HIA guidelines.

c. *Who provides the surveillance information?* if the time scale meets the needs of time-series analysis and HIA, European agencies (EEA, EUROSTAT) will provide the data. For local data, there can be different situations depending on the APHEIS centres (see Epi guidelines).

d. *How is the information transferred?* Different possibilities will be identified depending on the centres.

e. *How is the information stored?* The data gathered and processed by each centre will be stored in each centre in an APHEIS database.

f. *Who analyses the data?* Time series analysis requires experienced statisticians, adequate statistical resources and prior training and support from the centres with experiences in these methods. Calculations for HIA can be done in each centre after training to use the AirQ software for health-impact assessment developed by WHO. An evaluation of the AirQ software will be made in order to test its adequacy for the APHEIS project.

g. *How are the data analysed and how often?* Time series analysis requires 3-4 years of retrospective continuous daily data. Details on time series analysis and HIA calculations are given by the Stats and HIA guidelines.

h. *To whom the reports are distributed?* The reports will be distributed to European public health authorities and environmental agencies, and to WHO-ECEH. Potential users at the local and national levels will be defined in each APHEIS centre.

i. *How often will reports be disseminated and how will they be distributed?* These questions will be answered depending on the needs of the European Commission, WHO and the local authorities in further steps of the programme.

1.3.4. Usefulness

Some of the benefits of the programme can be summarised as follows:

- Provide effect estimates and exposure-response functions for HIA that are representative of 26 cities of 12 European countries.
- Generate bridges between environmental, health and other professionals.
- Contribute to the training of environmental health professionals.
- Guide and optimise the measurement of air pollutants so that they meet the needs of public health monitoring.
- Identify the relationship of episodes (or air pollution peaks) to background levels and the various pollution mixtures which are observed over the year.
- Evaluate interventions and the effectiveness of different scenarios of reduction of air pollution levels at the European, national and local levels.
- Evaluate scientifically the local applicability of national and international guidelines.
- Contribute to the development of environmental health indicators which are easily understood by decision-makers.
- Propose the creation of a “virtual” decentralised APHEIS database that would allow gathering information needed for research (eg. better information on effect modifiers) to test new hypotheses on the impact on health of various types of air pollution and generate hypotheses on the aetiology of the effects of pollution on health.

- Increase the participation of citizens by providing them with clear information on the impact of air pollution on their health.

1.3.5. Attributes

The public health surveillance system should be developed considering the following attributes:

Simplicity. Surveillance systems should be as simple and inexpensive as possible while still meeting their objectives. Some issues that should be kept in mind are:

- Amount and type of information to be collected.
- Number and type of reporting sources.
- Methods of transmitting the information
- Staff training requirements
- Type and extent of data analysis
- Number and type of users of compiled information
- Methods of dissemination to these users
- Time spent with the following tasks: a) maintaining the system, 2) analysing and 3) preparing and disseminating surveillance findings.

Flexibility. This means how easily the surveillance system can adapt to changing information needs or operating conditions with little additional cost in time, personnel, or allocated funds.

Acceptability. This is a crucial point, the success of the system relies on a solid local organisation and the willingness of individuals, organisations and authorities to make the system work. Given that in most cities, public health and environmental departments are separated, some resistance may exist from environmental organisations in providing data to public health departments. When a normative does not exist to establish a surveillance system of the effects of air pollution on health, special care should be taken when establishing the model of organisation for solving this anticipated resistance. One possible strategy can be to involve data providers in the project, not only as providers that regularly receive feed-back information, but as full partners of the programme.

Representativeness. The representativeness (in terms of person, time and place) of the exposure and the health data should be assured. Two questions are of special interest in the case of the air pollution and health surveillance system:

a) *To what extent the monitoring sites are representative of the population exposure?* We know that only certain components of the complex mix of outdoor pollutants are measured routinely and that the correlations between fixed monitoring sites and individual measures may be different depending on the pollutant. But for time series what is important is the temporal correlation between fixed monitoring sites and personal exposure. For PM_{10}, recent studies suggest that temporal correlations between fixed and individual measurements are high and although these findings cannot be extrapolated to gases, they provide sound reasons for using indicators from fixed monitoring sites for time series studies[68-72].

b) *To what extent the hospital data we collect are representative of all the admissions of the population studied?* Hospital admissions data should be representative of the total admissions in the study area covered by the local air pollution network.

Timeliness. The delays in the different steps of the production of the information depend on the availability of the required data in each centre and in the European agencies. These delays have been investigated and findings are reported in the second part of the report.

1.3.6. Resources

Resources for the coordination of the programme have been defined in the planification of the project. Local resources have been preliminarly identified through a questionnaire presented in the second part of the report. In the implementation phase, these resources will be defined more precisely.

1.3.7. Modality of organisation

The Public Health Advisory Group will optimise the use of information for public health actions. This means a local modality of organisation that guarantees the availability of data and an effective and efficient dissemination of the results. Given that in most cases, the institutions that provide health and environmental data are not the same that those who analyse them and disseminate the findings, feed-back of these findings and discussion about the dissemination strategies between these two different levels is of crucial importance and will be treated in the implementation phase.

1.4. Summary of the components of the surveillance system

	Description	Who elaborates the guidelines
1. Public health surveillance		PHAG
2. Importance of the problem		PHAG
3. System description		
3.1. Objectives		All the advisory groups
3.2. Events under surveillance		All the advisory groups
3.3. Components of the system		
3.3.1. Data collection	Identification of exposure data	EAAG
	Sources of exposure data	
	Transfer of exposure data	EAAG
	Storing the exposure data	EAAG
	Identification of health data	EAG, HIAG
	Sources of health data	
	Transfer of health data	EAG, HIAG
	Storing the health data	EAG, HIAG
3.3.2. Data analysis	Who analyses the data How are the data analysed How often the data are analysed	SAG, EAG, HIAG
3.3.3. Dissemination of results	Who elaborates the reports? To whom the reports are distributed How are the reports distributed?	PHAG
3.4. Usefulness	To identify potential uses (actions, research) derived from the surveillance system	PHAG
3.5. Attributes of the system (to be kept in mind when elaborating the guidelines)	Simplicity Flexibility Acceptability Representativeness Timeliness	All advisory groups
3.6. Resources	Available resources in each centre and in the coordinating centre	PHAG
3.7. Modality of organisation (to assure data collection, analysis and dissemination)	Potential partners, commitment and channels of communication	PHAG

Note: EAAG=Exposure assessment advisory group; HIAG=Health impact assessment advisory group; SAG=Statistics advisory group; EAG=Epidemiology advisory group; PHAG=Public Health Advisory Group.

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GUIDELINES ON EXPOSURE ASSESSMENT

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GUIDELINES ON EXPOSURE ASSESSMENT

2.1. Introduction

In this chapter, the exposure assessment strategy developed under APHEA will be discussed and revised in the light of recent developments in WHO and EU air quality policies, in order to make recommendations for the APHEIS programme.

2.2. APHEA Guidelines on Exposure Assessment

During the first meeting of the APHEIS programme, it was suggested that the exposure assessment strategy, i.e. the establishment of the most appropriate exposure indicators for epidemiological surveillance and health impact assessment in particular, should be based on the APHEA2 protocol (APHEA2, 1st meeting, Munich, 14 February 1998). The following strategy was proposed in this protocol:

2.2.1. Air quality indicators

– Sulphur dioxide: 24-hour average

– Nitrogen dioxide: maximum 1-hour daily value

– BS, TSP, PM_{10}: 24-hour average

– Carbon monoxide: maximum 8-hour average (based on 8 hour moving average)

– Ozone: maximum 8 hour (preferably calculated as 8 hour moving average and, if possible, 8 hour average from 9 am to 5 pm), and maximum 1 hour daily value.

This means that for each city five series for gaseous pollutants plus as many as available particles data.

2.2.2. Site selection criteria

The APHEA2 protocol defines that measurements stations in the vicinity of highways or industrial sources should be excluded from the analysis. Daily air pollutant measurements should be provided by the monitoring networks established in each participating town. Since only urban air pollution is considered, air pollution monitoring sites situated outside urban areas will not be used, except for O_3 (due to its special pattern of spread).

2.2.3. QA/QC of air quality data

"There was no quality assurance or quality control programme within APHEA to ensure comparability of air pollution measurements"[1].

Concerning the data quality objectives, the APHEA2 protocol refers to the following:

Completeness criteria

For the calculation of 24 hour NO_2 and SO_2 and maximum one hour NO_2 values, it is required to have at least 75% of the one hour values on that particular day. For the maximum one hour O_3 values, 75% of the hourly values from 6am to 7pm have to be available, since the maximum O_3 levels always occur during day-light. For the eight hour value of O_3, it was decided to take the 9am to 5pm average (since O_3 peaks at or immediately after mid-day and this eight hour average is probably identical or very

close to the maximum), and to calculate this, at least six hourly values have to be available. If a station has more than 25% of the values missing for the whole period of analysis it is excluded. In some centres a station may have been closed for a long period. If a nearby station is operating, measurements may be substituted. In this situation, care is taken not to introduce a systematic error, because in some cases a nearby (in geographic terms) station, may give systematically different values. In such a case an adjustment may be done (for example if the levels of the substitute station are systematically higher by 25% they are multiplied by 0.8).

Missing data

For each pollutant, a series consisting of the arithmetic mean of daily values of all monitoring stations that fulfill the inclusion criteria, will be constructed. Despite the completeness criteria, there will still be missing values in the air pollutant series for some days (usually for a small proportion of days). Missing air pollution data will be filled in accordance with the following procedure. The value in a day with missing data in a monitoring station *j* in the year *k* will be replaced by the weighted average of the values of the rest of the monitoring stations, i.e.

$$X_{ijk} = \bar{X}_{i.k} * (\bar{X}_{.jk} / \bar{X}_{..k})$$

For days with missing values in all used monitoring stations, the resulting series will also have a missing value on that date, but this should be a small percentage of the time series. Provided this is less than 5%, the final decision taken during the last Santorini Workshop was to replace these days by using the average of the value of the pollutant of the previous day (to the one with the missing value) and the next day, if these are not missing as well. In case there are consecutive days with missing values they will not be filled in.

2.3. Recent Developments in WHO and EU Air Quality Policies

2.3.1. WHO Air Quality Guidelines

The first edition of the WHO Air Quality Guidelines for Europe was published in 1987. This publication included health risk evaluations for 27 pollutants. It was the aim of the Guidelines as stated in the first edition to provide a basis for protecting public health from adverse effects of environmental pollutants and eliminating or reducing to a minimum exposure to those pollutants that are known or likely to be hazardous to human health or well-being. Although health effects were the major consideration in establishing the Guidelines, ecologically based Guidelines for preventing adverse effects on terrestrial vegetation were also considered, and guideline values for vegetation protection for nitrogen- and sulphur oxides and ozone have been established.

The Guidelines are intended to provide background information and guidance to national or international authorities in making risk assessment and risk management decisions. In providing pollutant levels below which exposure, for lifetime or for a given period of time, does not constitute a significant public health risk, the guidelines form a basis for setting (inter)national standards or limit values for air pollutants.

In general, the guidelines address single pollutants, whereas in real-life exposure to mixtures of chemicals occur, with additive, synergistic or antagonistic effects. Although the WHO Air Quality Guidelines are considered to be protective to human health they are by no means a “green light” for pollution and it should be stressed that attempts should be made to keep air pollution levels as low as practically achievable.

The Guidelines do not differentiate between indoor and outdoor air exposure because, although the site of exposure is determining the type and concentration of air pollutants, it does not directly affect the exposure-response relationship.

It should be emphasised, however, that the Guidelines are health based or based on environmental effects and are not standard per se. In setting legally binding standards also other considerations such

as prevailing exposure levels, technical feasibility, source control measures, abatement strategies, as well as social, economic and cultural conditions must be taken into consideration. Consequently (inter)national standards may be above or below the health-based WHO Air Quality Guidelines.

Since the publication of the first edition of the WHO Air Quality Guidelines new scientific data in the field of air pollution toxicology and epidemiology have emerged and new developments in risk assessment methodology have taken place. These developments have necessitated updating and/or revision of the existing Guidelines. The Bilthoven Division of the European Centre for Environment and Health has undertaken the process of amending, updating and extending the existing Guidelines. This process was carried out in close cooperation with the International Programme of Chemical Safety (IPCS) and the European Commission (DG XI). The update and revision of the WHO Air Quality Guidelines were undertaken in several Working Groups between 1993 and 1996. They are published at the homepage of the WHO European Centre for Environment and Health, Bilthoven Division (www.who.nl).

2.3.2. WHO Publication on Health Impact Assessment

Recent efforts have been made in a WHO project[2] to define the features of monitoring networks that allow their use in assessing the potential exposure of the population to ambient air pollution. Most air quality monitoring systems do not fully address population exposure to toxic air pollution. The principles outlined are intended to promote progressive modification of the air quality monitoring networks to improve their usefulness for health impact assessment. Also parts of this work provides guidance which should practically be implemented into the APHEIS project.

2.3.3. EC Air Quality Framework Directive (Council Directive 96/62/EC)[3]

The Air Quality policy of the EC started in the mid-seventies, with the development of the directive on air pollution by sulphur dioxide and particulate matter, and the later directives for lead and nitrogen dioxide. The implementation of these early directives was often troublesome and sometimes ineffective. Mainly the poor comparability of air quality data obtained from different Member States caused major problems: incomplete data sets, poor data quality, different criteria for network design were so many reasons to call for a revision of these directives. The Directive on Air Quality Assessment and Management, also called the Air Quality Framework directive was therefore developed by the European Commission and adopted by the Council of Ministers in 1996. This directive defines the basic principles of an European strategy for the protection of human health and the environment as a whole. This directive constitutes the framework for the development of specific Daughter Directives for a series of pollutants.

Already with the development of the ozone directive in 1992, but definitely with the Framework Directive and the coming Daughter Directives, the philosophy of the directives changed in many ways, with important consequences for the assessment philosophy, in particular. Where the assessment objectives in earlier directives mainly concerned the control of compliance with limit values, these are now extended to the information of the public, the full assessment in terms of areas of exceedance and population exposed, the implementation of abatement measures and the control of their efficiency.

Special provisions are contained in the Framework Directive, that will ensure a better comparability of air quality data among the Member States: criteria for network design (siting criteria, number of sites), standardized and validated reference measurement methods, data quality objectives, requirements for the agreement of measurement systems (laboratories, methods, instruments), recommendations for the QA/QC of the measurements.

2.3.4. EC Daughter Directives

The first Daughter Directive 1999/30/EC[4] relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air (attached as 1DDt-99-30.pdf file) has been adopted by the Council of Ministers in June 1999 and will be brought into force the national regulations and ordinances of the EU Member States by July 2001. The second Daughter Directive

2000/69/EC[5] relating to limit values for carbon monoxide and benzene in ambient air was adopted in November 2000 and will be brought into force by December 2002. With regard to the other Daughter Directives, new target values for ozone are currently in preparation as well as proposals for further directives relating to limit values for heavy metals and poly-aromatic hydrocarbons.

It is important to note that the limit values of the Daughter Directives are based on the revised WHO Air Quality Guidelines for Europe (1997). In addition, the results of the APHEA and PEACE studies have been similarly determining in the establishment of these limit values. Due to this, the health impact of air pollutants are better considered than ever before in the EC directives. The Advisory Group on Exposure Assessment therefore highly recommends to take over parts of the guidelines of the first Daughter Directive into the exposure assessment strategy of the APHEIS project.

The directives are formulated on the basis of Position Papers prepared by the EC with the support of European air quality experts. These documents present a state of the art on the knowledge for each single air pollutant, and contain relevant and information to the APHEIS project, in particular concerning origin and fate of the pollutants, risk assessment and measurement strategy.

2.4. Approach to Measurement Strategies under WHO and EU policies

2.4.1. WHO Policy

Chapter two of WHO, 1999 deals comprehensively with the relationship between information on air quality and population exposure. Herein it is mentioned that “Air quality assessment in general and specifically air quality monitoring should produce information that can be interpreted to indicate population exposure. Correctly determining population exposure requires knowing the population distribution and location of air monitoring stations to identify the population concentrations to which the population and different population subgroups in particular are exposed. Not only hot spots or areas where maximum concentrations are expected but also representative community sites where most of the population lives should be monitored. Monitoring ambient air quality that means outdoor air, and the monitoring sites are more or less fixed at selected locations. The population moves into, out of and across the community every day. The exposure estimated by using the ambient air concentration levels is the potential exposure of the population”. Various methods to assess population exposure using ambient air quality monitoring data are described in this WHO monograph too[2].

Chapter three of WHO, 1999 reviews comprehensively some of the requirements regarding design, operation and quality assurance and control (QA/QC) of monitoring networks for assessing population exposure to ambient air pollution. Harmonisation of measurement quality – at both a national and international level – should be promoted through national QA/QC co-ordination, laboratory accreditation and international validation programmes[2].

WHO Intercomparison Workshops on Air Quality Monitoring for SO_2, NO/NO_2, CO and O_3 gave first indications on the comparability of measuring methods (manual and automatic) used by air monitoring network authorities in Western, Central and Eastern Europe, but under laboratory conditions only[7,8].

The definition of clear data quality objectives is essential to enable networks to be optimally designed, priority pollutants and measurement methods to be selected and requirements for data management and reporting to be identified. With regard to the recommendations of WHO, 1999 following requirements are to be achieved: measurement accuracy and precision, adaptable to metrology standards, temporal completeness (data capture), spatial representativity and coverage, consistency from site to site over time, international comparability and harmonisation.

2.4.2. EC Policy

The following provisions relevant to the exposure assessment strategy are contained in the 1st and 2nd Daughter Directives[4,5], as well as in the ozone directive proposal[6].

Air Quality Indicators

- SO_2 (1h, 24h, 1 year),
- NO, NO_2 (24h, 1year),
- PM_{10} (24h, 1 year), $PM_{2.5}$ (24h, 1 year)
- Lead (1 year)
- CO (8h),
- O_3 (1h, 8h),
- Benzene (1 year).

Site selection criteria

As part of the provisions of the Framework Directive to ensure the comparability of air quality data, the Daughter Directives contain harmonised criteria for the design of the measurement networks.

With regard to the protection of human health, fixed measurements should be sited such as:

– to provide data on the areas within zones and agglomerations where the highest concentrations occur to which the population is likely to be directly or indirectly exposed for a period which is significant in relation to the averaging period of the limit value(s);

– to provide data on levels in other areas within the zones and agglomerations which are representative of the exposure of the general population.

The sites to be selected should be representative of the exposure of population and take into account the time scale of their effects on health: for pollutants with acute effects (e.g. SO_2) also peak values in hot spots should be considered, whereas for pollutants with long-term effects (e.g. benzene), only background levels are of relevance.

Detailed criteria on the location of the sampling points are given in the relevant technical annexes of the Daughter Directives.

Number of stations

The same technical annexes give further criteria for determining the minimum number of sampling points for fixed measurements. These annexes have to be seen in context with the requirements for the assessment of concentrations of within a zone or agglomeration.

Measurement Methods

For each single pollutant, the directives give reference methods for the assessment of concentrations. The reference methods of the directives are currently being standardised by the European Standardisation Committee (CEN) in the framework of EC mandates.

Besides the reference measurements methods proposed by the directives, the Member States are allowed to use whatever other method provided they can demonstrate the method to produce equivalent results or to show a consistent relationship to the reference method. Equivalence is obtained if all the data quality requirements established for each single pollutant and expressed in terms of accuracy, data coverage and data availability are respected.

Assessment of population exposure

For the assessment of population exposure, a combination of the spatial distribution of both air quality and population density are required. If most of the monitoring networks are able today to assess the air quality in the single stations of the monitoring network, the mapping of air pollutants over an area of interest, constitute a new challenging task. In order to fulfil this task, two approaches are possible: the use of screening techniques for the experimental assessment of the pollutant distribution, or the use of mathematical models. The Guidance Document on Preliminary Assessment[9] of the EC provides different methodologies for the spatial assessment of the air pollutants.

Data Quality Objectives

The technical annexes of the EC directives define more extensive data quality objectives for the required accuracy of assessment methods, for minimum data capture (data completeness) and time

coverage. These various requirements are laid down for the selection of the most appropriate assessment methods and to guide the quality assurance programmes.

Accreditation of laboratories

The EC directives require that the laboratories responsible for the assessment of the air quality be approved in accordance with, inter alia, the requirements of European quality assurance standards. This refers to the EN 45000 standards concerning the accreditation of laboratories. In application of these standards a laboratory may obtain a formal recognition of its competencies to perform a certain activity by an independent accreditation body.

Accreditation is the formal recognition, authorisation and registration of a laboratory that has demonstrated its capability, competence and credibility to carry out the tasks it is claiming to be able to do. Accreditation is granted by an independent body and relies on the recognition of the competence by peers, i.e. people of the same profession. This competence is expressed in organisational terms as well as in terms of technical skill. Moreover, a laboratory is never accredited as a whole, but only for a set of well defined and validated methods. An accredited laboratory is able to demonstrate and document the technical training of staff, traceability of measurements and traceability of data and documents.

QA/QC of the measurements

In order to ensure a harmonised implementation of EC Air Quality directives, the European Commission carries out Quality Assurance programs for the various pollutants regulated by the directives. These programmes are implemented by the European Reference Laboratory of Air Pollution (ERLAP) of the Joint Research Centre in Ispra (Italy) in collaboration with the EU Member States[10,11]. These programmes include different activities, such as:

- the validation of sampling, calibration and analysis methods in laboratory and field conditions;
- the participation to ISO and CEN activities for the standardisation of measurement methods;
- the organisation of inter-comparisons to test the calibration methods implemented in the national central laboratories;
- the organisation of quality controls of air quality measurements in the EU monitoring networks;
- the organisation of pilot studies for the design and optimisation of the monitoring networks;
- the publication of guidance documents on monitoring strategies for network managers and operators.

With the new directives, Member States are requested to participate to theinter-laboratory exercises regularly organised by the Commission. These exercises are organised by the JRC in collaboration with the national reference laboratories with the objective to control the quality and the comparability of the measurement methods implemented in the Member States. Since 1999, these exercises are organised on a routine basis simultaneously for sulphur dioxide, nitrogen oxides, ozone and carbon monoxide. From the year 2000 on, these programmes have been extended to the countries currently in the accession phase. Similar activities will be initiated in the next future for the other pollutants covered by the new Daughter Directives, i.e. for benzene, PM_{10} and $PM_{2.5}$, poly-aromatic Hydrocarbons and heavy metals (Pb, Cd, Ni, As, Hg).

2.5. Data Availability

AIRBASE

AirBase is the air quality information system of the EEA[12]. It contains a database carrying information submitted by participating countries from across Europe. This information comprises air quality data for a selection of stations and a number of components, and meta information on air quality

monitoring networks and stations. The two preceding EU databases APIS (Air Pollution Information System; air quality data) and GIRAFE (meta information on air quality networks and stations) have been included and replaced. The AirView web-application facilitates free access to all information contained in AirBase. The current database contains information which was transmitted by EIONET partner states in the framework of 'Exchange of Information' (EoI) Decisions, or as part of Euro Airnet. To this end the Data Exchange Module (DEM) was designed to facilitate data transmission. The AirBase information system further contains a web-application to facilitate free access to all information contained in the database (AirView), and a Model Documentation System (MDS) providing access to model characteristics for potential model users.

The AIRBASE information system is developed and maintained by the European Topic Centre on Air Quality on behalf of the European Environment Agency. More information on the AIRBASE database can be downloaded from the ETCAQ web-site (http://www.etcaq.rivm.nl/databases/airbase.html).

EUROAIRNET

The main goal behind the establishment of the Europe wide air quality monitoring and information network of the EEA (EUROAIRNET)[13] is to improve significantly the reporting of air quality data in Europe, with a coverage that makes possible comprehensive assessments of European air quality within a year or a little more after the end of a monitoring year.

The aim of EUROAIRNET is to provide information to support and to facilitate the assessments of air quality to be produced by EEA. The information is available in such a form that it is suitable to:

– facilitate a general description of air quality across Europe, and its development over time (trend);
– enable comparison of air quality across Europe;
– produce estimates of exposure of the European population, and of materials and ecosystems;
– estimate health effects;
– quantify damage to materials and vegetation;
– produce emissions/exposure relations and exposure/effect relations;
– support development of cost-effective abatement strategies;
– support the framing and implementation of legislation (in relation to air quality directives);
– influence/inform/assess effectiveness of future/previous policy.

The assessments are based upon concentration fields (space-time fields) produced by the monitoring and information network or by a combination of monitoring and modelling, and covers local as well as regional scales. The modelling efforts are essential in forming the links between emissions on the one hand and exposure and effects on the other hand.

The EUROAIRNET information system is developed and maintained by the European Topic Centre on Air Quality on behalf of the European Environment Agency. More information on the EUROAIRNET database can be downloaded from the EEA web-site (http://eea.eu.int).

2.6. Proposal for APHEIS Exposure Assessment Strategy

Based on the above considerations, for the definition of the APHEIS exposure assessment strategy, it is advised to take advantage of the general provisions developed under the WHO and EC policies with respect to human health.

Also, the most important issue for HIA is that exposure has to be measured in the same way in each centre.

In addition, the following specific requirements are proposed for the APHEIS exposure assessment:

2.6.1. Air quality indicators

With regard to the air quality indicators, the selected parameters should be easily available, be indicative of the health risk to the population and relevant to the time scale of the pollutants effect.

The new EC directives will begin to be implemented in 2001, in the meanwhile, the APHEA criteria on AQ stations completeness and on procedures to impute missing values were agreed upon *(see above section 2 APHEA2 methodology*).

After discussion at the second APHEIS meeting in Ispra, the following parameters are proposed:

- **Sulphur dioxide** (SO_2): short-term effects, urban background levels, 24h average (1 hour as optional indicator where available)
- **Nitrogen dioxide** (NO_2): short-term effect, urban background levels, 24h average (Nitrogen monoxide 24h average and NO_2 1h as optional indicators where available)
- **PM_{10}:** short-term effect, urban background levels, 24h average (**Black smoke:** 24h average is strongly recommended by the Epi AG, but as optional indicator; and $PM_{2.5}$: as optional indicator where available)
- **Carbon monoxide** (CO): short-term effects, urban background levels, 8h running average.
- **Ozone** (O_3): short-term effects, rural background levels, 1 hour maximum concentration and 8h maximum of daily moving average. The sum of oxidants (ozone + nitrogen dioxide) has been proposed as an optional indicator as ozone levels are very homogeneously distributed at regional level, but because of its reactivity it readily reacts in the lower troposphere with nitrogen monoxide emitted essentially by traffic to produce nitrogen dioxide. The sum of the oxidants is generally constant over a larger area and is usually equal to the maximum daily value of ozone alone. The sum of oxidants may provide a better estimation of the health risk than the maximum 8h moving average of ozone. In addition, ozone is an indicator of other probably more toxic oxidants (aldehydes, ketones, PAN, PBN, free radicals) which are generally not measured in the monitoring networks.
- **Benzene**: long-term effects, urban background levels, yearly average.

2.6.2. Site selection criteria

Only measurements performed in areas representative of the exposure of population at large will be considered, taking into account the time scale of their health effects. Typically this limits the measurement stations to urban background locations, excluding sites in the direct vicinity of traffic or of industrial sources. However, for pollutants with acute effects (e.g. SO_2) also peak values in hot spots need to be considered, whereas for pollutants with long-term effects (e.g. benzene), only background levels are of relevance.

For the site selection criteria of APHEIS it is recommended to use the requirements established under EC Directives (see 2.4.2).

Site modifications in air monitoring networks, following for example an improvement of the air quality situation, may raise problems for the selection of monitoring sites for studies in the long run. For the selection of measurement sites, it was suggested at the first APHEIS meeting, to select monitoring sites which are foreseen for a long-term run by the air monitoring network operating authorities.

The first APHEIS meeting also suggested that when changing the measurement method at a measurement site it is important to run concurrent measurements for one year to evaluate the impact of changes[14].

2.6.3. Number of stations

Criteria for determining the minimum number of exposure relevant sampling points for fixed measurements should take into account:

- the area to be covered
- the spatial variability of pollutants
- the availability of resources

Because health monitoring requires large populations in order to generate sufficient counts of health events [14], single monitors may be insufficient to assess the population exposure. It is strongly

recommended that a number of monitoring stations is used to reflect the exposure of the population at risk. These stations should comply with the site selection criteria described under 2.6.2.

2.6.4. Measurement methods

The measurement methods used for air quality assessment should be reported by each centre (for example UV Fluorescence, Chemiluminescence, UV Absorption, Beta absorption, TEOM, Gravimetry, Reflectometry, for Black Smoke the type of reflectometer and the filter type, …).

2.6.5. Data quality

The data quality requirements developed under the EC Air Quality directives are proposed. Air quality data are in general available from the national air quality agencies. They are also available on-line from the EEA databases (AIRBASE and EUROAIRNET). These data are usually validated and of known and documented quality.

Whenever other sources of air quality are considered, for example from local networks, the following requirements apply:

Data quality objectives

The essential requirements on data quality to be met by the local networks are:

- Known measurement uncertainty
- Data completeness (data capture and coverage)
- Spatial representativity and coverage
- Consistency from site to site and over time
- National and International comparability and harmonisation

Quality assurance and control

The major components of quality assurance are:

- Well defined monitoring and data quality objectives
- Well defined criteria for network design and site selection
- Selection and evaluation of measurement methods and equipment
- Management of the laboratory and training of personnel

The major components of quality control are:

- Controlling routine site operations
- Establishing a chain of calibration and traceability
- Internal and external audits (inter-calibration and inter-comparisons)
- Maintaining and supporting systems
- Reviewing and managing data

2.6.6. Assessment of population exposure (mapping)

Mapping air pollutants over an area of interest is a new challenge. Two approaches are possible: a) use of screening techniques for the experimental assessment of the pollutant distribution, and b) mathematical models. The future collaboration between APHEIS and EUROHEIS projects (UK) will help dealing with this issue.

2.7. Transfer of exposure data

The new European Directive states in Article 8 ‘Public information’ of 1999/30/EC:’ Member States shall ensure that up-to-date information on ambient concentrations is routinely made available (on at

least a daily basis) to the public as well as to appropriate organisations, such as relevant health-care bodies by means of e.g. computer-network services'.

The new EC directives will begin to be implemented in 2001. However, it should be noted that historical time series of air quality data collected under the EC APIS and GIRAFE programmes are available on the EEA databases.

2.8. Storing of exposure data

The exposure data collected by each centre will be stored first at the local APHEIS centre, then it will be transferred to the APHEIS coordinating centre to allow data analysis.

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GUIDELINES ON EPIDEMIOLOGY

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3.1. Objective

The objective of the Epidemiology AG is to advise on the data needed for epidemiological surveillance in the APHEIS programme.

3.2. General principles

A Surveillance system, in order to be operational and yield useful results, should be kept simple. This also ensures **comparable** results across centres. The data needed to implement the epidemiological surveillance can be classified in 4 categories – exposure, outcome, confounder and effect modifier – and will be described in that sequence.

The distinction between surveillance of short-term and long-term effects studies will be made: APHEIS will analyse short-term effects of air pollution on health on a regular basis and will also monitor the long-term trends over time.

It is hypothesised that the APHEIS surveillance system will be implemented by an institute that will be defined in each specific country or area. It will be responsible for gathering and processing the data in collaboration with the data "sources"; conducting specific analyses (guidelines by the statistics AG) and disseminating results. This institute will be called the "APHEIS centre".

3.3. Background evidence

The epidemiological surveillance of short-term effects of air pollution is based on time series studies. Many studies of this type have been published during the last decade and the results are remarkably consistent and converging in indicating effects of moderate and low levels of air pollutant concentrations on health. In addition, there are published estimates from meta-analysis of several time-series studies, the use of which is encouraged, as they are based on more extended and diverse data sets. There is a reasonable consensus on the results of such studies[1-10]. With this approach, it is supposed that daily death counts follow a non-stationary overdispersed Poisson process, where variations could be partly explained by time-varying factors, ie air pollutants concentrations, which are here the exposure of interest, and several other variables, which are here considered as potential confounders[11-12]. It should be made clear, that time series studies, by definition, do not provide estimates of long term effects of air pollution on health.

The evidence on long term effects is based on a very limited number of U.S. studies. They indicate a considerable impact on health[13-14]. The precise quantitative estimates produced by these studies may be considered cautiously and the extent to which they can be geographically extrapolated is not clear. We therefore propose the use of these estimates as **indicative** of the overall effect of air pollution[15].

The specific requirements for epidemiological surveillance are the following:

3.4. Exposure Data

Since past exposure is useful mainly for monitoring the long-term trends over time in each area, a historical data file on exposure must be constructed in each area, including data from the beginning of routine monitoring.

The surveillance system will be based on existing monitoring networks. These may be either government or municipal. The best would be, as recommended by the Exposure AG, to collaborate

with the Agency responsible for implementing the EC provisions under Council Directives 96/62/EC, 27 September 1996 and 1999/30/EC, 22 April 1999. In Annex VI of the second directive (1999/30/EC) there are guidelines on the number and location of monitoring points. We propose to collect routine exposure data from the system network, which adheres to these guidelines.

The pollutants to be taken into account have been defined by the Exposure AG. The agency responsible for data collection should provide the APHEIS Centre with measurements on the pollutants listed above, for averaging times corresponding to the revised WHO/Air Quality Guidelines for Europe which are in press.

For the purpose of time series analysis the indicators should be based on 24-hour average values or maximum 1 hour or 8 hours values depending on the indicators. When the averaging time is 24 hours, we will request one value for each day. When the averaging times are smaller (i.e. 1 hour or 8 hours) we will request the maximum daily concentration and the number of the corresponding periods per day when the limits of 1999/30/EC directive and future similar directives for other pollutants are exceeded.

Set of core indicators for epidemiological surveillance: PM_{10} 24-hour average, SO_2 24-hour average, NO_2 24-hour average, CO maximum 8 hours, O_3 maximum 1 hour and 8 hours.

Set of additional indicators: Black Smoke 24-hour average, $PM_{2.5}$ 24-hour average, SO_2 1 hour, NO_2 maximum 1 hour, NO 24-hour average, $NO_2 + O_3$ 24-hour average, Benzene 24-hour average.

The collection of Black Smoke is strongly recommended and, where available, both PM and BS should be analysed.

The exposure data should be provided in electronic format.

The time delay necessary for data availability was agreed on one year. It should be stressed that APHEIS is not an alert system although estimates will be able to be provided for high levels found in air pollution episodes.

3.5. Outcome Data

Aggregated data will be requested. The aggregating area will correspond, in each case, to the area covered by a monitoring system according to Annex VI of 1999/30/EC. The aggregating time will be 24 hours (calendar day).

The delay for data availability will be, whenever possible, one year.

The outcome data should be provided in electronic format.

It is proposed for the time being to keep the data collection to a minimum but some centres may be able to collect and process additional indicators.

The series requested will include (note that ICD codes below are given for the 9th revision; the correspondence with the 10th revision must be provided, if this revision is used):

3.5.1. Mortality data

Data on mortality will be recorded by age group and by cause of death. Three series of mortality will be analysed:

- Total daily number of deaths (excluding deaths from external causes i.e. excluding those with ICD9≥800),
- Respiratory (ICD9:460-519)
- Cardiovascular (ICD9:390-459).

Three age groups will be considered: 15-64 years; 65-74 years; 75+ years and all ages.

The mortality data will generally be provided by Mortality Registers.

3.5.2. Morbidity data

Set of core health indicators to be collected by each centre:

- ♦ Hospital Admissions Respiratory (ICD9 460-519)
- ♦ Pneumonia and acute bronchitis hospital admissions (ICD9 466, 480-486)
- ♦ Hospital Admissions Cardiac (ICD9 410-414, 427, 428).

Four age groups will be considered <15 Years, 15-64 Years, 65-74 Years, 75+ Years.

The hospital admission data provision will depend on the national collection system and will generally use the first discharge diagnosis.

Set of additional health indicators to be collected on a voluntary basis by the centres:

If emergency admissions (or good data on emergency visits) are available, they can be used instead or in addition to total admissions; codes as above.

If in a specific center, any other morbidity indicator is well defined and operational for a long time, then it may be used as an additional health indicator.

3.6. Confounders

To assess the short-term effects of air pollution, only confounders varying with time must be taken into account. For this purpose we need for every day:

– day of week
– if it is a holiday (bank, school)
– daily number of influenza admissions (ICD9 487) or other sources on influenza epidemics
– unusual events (strikes, etc.)
– sharp reduction of the population
– 24 hour average, minimum and maximum temperature (°C)
– 24 hour average relative humidity(%)
– 24 hour average dew point
– 24 hour average total pollen counts

Confounders on long-term relationships are factors associated with the studied outcomes and perhaps the exposure. If available, the most important, on an annual basis, are:

– population in the study area by sex and age in 5 years groups
– prevalence of chronic respiratory disease by sex and age in 5 years groups
– smoking prevalence by sex and age in 5 years groups
– occupational exposures (optional)

3.7. Effect Modifiers

It has been hypothesised that certain variables may act as effect modifiers in the air pollution health association. There is some recent evidence from the APHEA project and other studies that this may be true.

The effect modifiers characterise an area and the associated population and may be classified in 5 categories:

- ➢ Variables characterising the air pollution mix and levels such as: annual and seasonal level of each pollutant; the ratio of $PM_{2.5}/PM_{10}$, NO_2/PM_{10} and black smoke/PM_{10} (if available); correlation coefficients between different pollutants and between different monitoring sites for one pollutant.
- ➢ Variables characterising the climate: annual and seasonal temperature and humidity.

- ➢ Health status of the population on an annual basis: standardised mortality rate by sex and age in 5 year groups; and lung cancer mortality rate by sex and age in 5 year groups; COPD deaths by sex and age in 5 year groups; cardiovascular deaths by sex and age in 5 year groups; lung cancer incidence rates by sex and age in 5 year groups; percentage of persons over 65 years of age; smoking prevalence; unemployment rates; educational level; poverty rates.
- ➢ Geographical area: a division in East/West and North/South; latitude-longitude.
- ➢ Time-activity patterns of the population (how much time is spent indoors, outdoors and in different means of transportation).

There is probably no uniform source for the information in sections 3.6 and 3.7.

- ♦ Meteorological parameters can be obtained from Observatories in each area.
- ♦ The number of influenza admissions from the same Agency as the outcome series on respiratory admissions.
- ♦ There is an existing, properly working European Aeroallergen Network (EAN), which could provide daily pollen data for APHEIS project. (http://www.univie.ac.at/ean/public),
- ♦ EUROSTAT may also provide some of the data required (http://wwww.datashop.org-email:dslux@eurostat.datashop.lu).

Some of the confounders and effect modifiers mentioned above may not be readily available for the population needed and special care should be taken by the APHEIS centres when collecting this information.

3.8. Combined analysis

In addition to the individual city or area analysis, there is considerable interest in a combined analysis to be undertaken at National or European level. The use of combined effect estimates in this case, gives more valid, accurate and generalisable results, given that in one city there is a higher probability of specific biases. These tend to cancel out when more areas are combined.

For the combined analysis, differences in practice and data collection will be important in interpreting national and international comparisons, so the epidemiology group requires a minimum description of the sources of information and the data collection process in each centre.

Regarding the question of extrapolation, we have to encourage the centres to make HIA in order to look at their local data and identify what are the lacks in the data and reinforce the strategy in order to have a good estimate for exposure. Moreover, rather than extrapolating an estimate from one city to another, we strongly recommend to get a global estimate of all the cities from the combined analysis (see HIA guidelines).

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GUIDELINES ON HEALTH IMPACT ASSESSMENT

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4.1. Introduction

The aim of health impact assessment (HIA) is to quantify the expected number of people with a health effect that could be attributed to a specific exposure situation[1]. In our context, HIA may play a role in the evaluation of different policy scenarios of reduction of air pollution levels, or in the assessment of new air quality directives, or in projects aiming at calculating the external monetary costs of air pollution or the benefits of preventive actions. The output of the HIA process will be the number of events attributable to air pollution in the target population. Epidemiological studies play a central role in estimating these attributable cases. The distinction and overlap between effects of long-term and short-term exposures should be specifically addressed, as the definition of the time window is important in the HIA.

Following the recommendations of WHO guidelines on assessing and use of epidemiological evidence for Environmental Health Risk Assessment[1], the major steps in the process of HIA are summarised here:

- specify the purpose of the assessment, associating decision-makers, scientists, and stakeholders;
- specify the methods used to quantify uncertainties in each step of quantification where uncertainties come into play and assumptions that have to be made;
- 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 attributable 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 exposure 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 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[2];
- 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 attributable 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. The uncertainties in the data that contribute calculation to the impact assessment, as well as natural sources of heterogeneity in the effect of exposure will often require the calculation of a range of estimates of attributable cases in order to describe fully the likely impact of exposure and better reflect the uncertainty.

Interpreting results of the HIA includes explicit discussion of assumptions and limitations. According to the recommendations of the WHO WG meeting in November 2000, only the impact estimates based on the long term studies are able to capture the cumulative effects of pollution on health. This refers, in particular, to the estimates of reduction of life-span attributable to the pollution. The estimates based on RR from time-series studies provide estimates of the changes in health indicators in the short term following the exposure. However, since the chronic effects of long-term exposure cannot be measured by time-series studies, the analysis based on such studies will, most likely, underestimate the total impact of pollution in a given population.

Sensitivity analyses in which the effects of key assumptions are explored quantitatively, may provide a better sense of the overall uncertainty of the estimates than purely qualitative discussions. Finally, attributable cases are often interpreted as the preventable fraction, meant to be prevented, had exposure been removed. Caution, however, is warranted with such an interpretation. First, the benefit of removal of a particular exposure may only rarely be estimated. The benefit may be realised much later than or not to the full extend, predicted. In our case, lower air pollution levels would take years to be fully realised. 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, it is well known for multicausal diseases that the sum of attributable cases across several risk factors does not add up to 100% but may be larger[2].

4.2. Objectives

The objective of health impact assessment (HIA) in APHEIS is to estimate the number of health events attributed to air pollution in the participating cities over a certain period of time. In principle, estimates for calendar year will be estimated. In each centre, the target population is the population covered by the air quality monitoring network in the study area, according to the Exposure AG. The adequacy of the exposure estimates for the target population should be assessed based on the available data from monitoring and pollution models, as well as expert judgement[3].

4.3. Components of the system

4.3.1. Data collection

In order to assess the impact of air pollution on outcomes (e.g., deaths, hospital admissions, asthma cases) in the target population for one year, the annual distribution of air pollution in different categories of exposure, the annual proportion of the target population in the exposure categories and the annual frequency of the outcomes are required in addition to the effect estimates derived from epidemiologic studies.

4.3.2. Population data

Demographic data in the target population (according to the APHEA2 protocol) should be obtained e.g. from the health data provider or the appropriate European agency: total number of population as well as gender distributed (man, woman) in 5 yr. age groups (Table 1) in order to be able to calculate age standardised mortality rates to a Standard European Population (Table 2).

Data should be based on the last census year or on yearly basis. Source of the data should be specified; if more than one exist (with possibly different information), the choice should be justified and the possible influence of the choice on the impact assessment should be considered in the sensitivity analysis. Mean numbers for 3-5 years can be considered as in the APHEA2 project.

The selected method of population enumeration should be clearly defined and recorded in each centre.

In big centres where relative risks for infant mortality may be calculated, annual number of live births and background infant mortality will be needed to make HIA.

Table 1: **Population in 5 yr age groups**

Year "X"	AGE GR	TOTAL POPULATION	MEN POPULATION	WOMEN POPULATION
	0 - 4 yrs			
	5 - 9 yrs			
	10 - 14 yrs			
	15 - 19 yrs			
	20 - 24 yrs			
	25 - 29 yrs			
	30 - 34 yrs			
	35 - 39 yrs			
	40 - 44 yrs			
	45 - 49 yrs			
	50 - 54 yrs			
	55 - 59 yrs			
	60 - 64 yrs			
	65 - 69 yrs			
	70 - 74 yrs			
	75 - 79 yrs			
	80 +			

Or a mean for the considered period (e.g. 3 to 5 years)

Table 2: **For age standardised mortality rate**

Year "X"	AGE GR	TOTAL DEATH	DEATH MEN	DEATH WOMEN
	0 - 4 yrs			
	5 - 9 yrs			
	10 - 14 yrs			
	15 - 19 yrs			
	20 - 24 yrs			
	25 - 29 yrs			
	30 - 34 yrs			
	35 - 39 yrs			
	40 - 44 yrs			
	45 - 49 yrs			
	50 - 54 yrs			
	55 - 59 yrs			
	60 - 64 yrs			
	65 - 69 yrs			
	70 - 74 yrs			
	75 - 79 yrs			
	80 +			

Or a mean for the considered period (e.g. 3 to 5 years)

Even if only some age groups will be of a particular interest for different health outcomes according to the existing scientific evidence, and will be considered in the data analysis, this information is important for standardisation.

The age-specific and age-standardised mortality rates will be used in comparisons between populations and interpretation of impact assessment estimates.

Any possible restrictions of the target population should be identified (e.g. admission to hospital restricted to people with certain insurance plan or a possibility to use of hospitals outside the surveillance area by a part of target population).

4.3.3. Exposure data

The Exposure AG should define the requirements for exposure data taking into account the specific considerations for HIA, that is the information required for calculating the annual distribution of air pollution in different categories of exposure. The following information will be needed:

1. Concentration of selected air pollutants (daily mean or maximum 8 hour mean) should be obtained from all relevant monitors covering the population (as defined by the Exposure AG), taking into account the APHEA2 protocol for:

   • Site inclusion/exclusion criteria
   • Dealing with missing data for one monitor at a certain day (formula from the protocol)
   • Dealing with missing days for all included monitoring sites

In principle, the information from background monitoring locations should be used.

2. Site characterisation (description, number, distance between sites, correlation between sites)

3. Exposure indicator (mean of concentrations from all monitors) should be calculated for the target population for each day

4. Frequency distribution of exposure should be created (format as for AirQ)

5. The range of exposure subject to evaluation should be defined.

The comparability of the exposure data should be ensured by providing the above information.

4.3.4. Health and effect modifiers data

Health and effect modifiers data as defined by the Epi AG, have to take into account the needs for HIA, that is the annual proportion of the target population in the exposure categories and the annual frequency of the outcomes, in addition to the effect estimates derived from pooled analysis or epidemiological studies.

Health data

At present, the set of core health outcomes considered and some of the additional ones, proposed by the Epi AG and also by AirQ, can constitute the list of possible health events to examine in relation with air pollution. If a health outcome can occur several times per year in one subject (e.g. hospitalisation due to exacerbation of COPD symptoms), each case should be recorded.

For HIA purposes, the underlying incidence of health event X in the target population is needed. If an effect modifier has been identified (e.g. age group) – the incidence for each level of the effect modifier will be necessary.

The number of cases of the outcome X (annual) in the target population should be collected. For each outcome, the following should be specified:

• Number of cases in the current year
• Number of cases in each of the previous 3 years
• Source of data
• Reference for methodology of registration of the health data of concern
• Possible sources of uncertainty in the data (e.g. registration of cases from outside of target population).

If the health outcome data for a given target population is not available, background incidence in an outside population should be identified. As a first approximation, the value from AirQ can be used. The possible bias should be discussed.

If the local frequency of the health outcome differs significantly from that observed in epidemiological studies used for derivation of the pollution-health relationship, it is possible that the definition of the health outcome indicator is different. Estimation of health impact using this indicator should then be critically evaluated and the decision might be taken to omit this indicator from the estimated set.

Effect modifiers

The information on possible effects modifiers should be collected according to Epi AG. This data will be used in the background of HIA and inter-city comparisons.

• Meteorological data (daily)

- Influenza cases (daily)
- Lung cancer incidence
- Smoking prevalence in the target population.

4.3.5. Exposure – response relationship

The question of which exposure – response relationship between outcome and pollutant should be used, the average of all cities, derived from a meta-analysis of the overall data, the city specific slope, or the extrapolation from one city to another have been discussed. As stated by the Stats AG, it is naïve to assume that the city specific slope is better, because it is derived from the city of interest. The situation is more complex. If for the specific outcome and pollutant of interest, there is no evidence of heterogeneity, then we must conclude that the variations of city specific slopes about the overall mean is purely stochastic. In that case, the population mean slope should be used. Often, heterogeneity will be present. This still does not mean that the city specific slope is the best estimate, however. In the case where heterogeneity is present, slope estimates vary about the population mean slope for two reasons. One is true heterogeneity in the slopes, and the other is still stochastic error. We would like a city specific estimate that reflects the first source of variation, but not the second. This is obtainable by using a shrunken estimate (for details see Stats AG guidelines).

Based on these statistical considerations, it was agreed that the basic model should limit the use of local estimates, in order to favour the use of more stable estimates from combined analysis, and to take into account some effect modifiers, favouring more stable relative risks. The process would imply using joint estimates and applying them to the local level.

Tables 3-5 give the relative risk estimates included as a default values in the AirQ programme (version December 2000). Besides the RR and its confidence interval, the table specifies the "strength of the evidence" for each RR. It is based on an expert judgement, and assigns the score "3" (good) to the RR resulting from meta-analysis of many studies, or evaluated, and quoted by WHO AQGs[4]. Score "1" (week) refers to RR from individual studies.

4.3.6. Data analysis

The data should be analysed:

a) by each centre – based on its own data. The APHEIS centres should be encouraged to do HIA in order to reinforce the local networking, with emphasis on exposure data quality

b) on a national level (if several cities from one country are coordinated by a national APHEIS centre

c) the results from all countries should be collated on a supra-national level, at the APHEIS coordinating centre, in collaboration with WHO-ECEH.

The methods used in AirQ taking into account, when possible, the Stats guidelines can be used to calculate expected proportion and number of cases attributable to the pollution in the analysed population. With further development of methods, the procedures for impact calculation may be modified.

The essential steps of data analysis used by AirQ are presented in Box 1

Box 1. Essential steps in health impact calculation[3]

An estimate of the impact can be based on the calculation of the attributable proportion (AP), indicating the fraction of the health outcome, which 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 exposure - consequence function, one can calculate the attributable proportion using the formula:

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

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

p(c) – proportion of 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:

$$I_E = I * AP$$

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

$$I_{NE} = I - I_E = I * (1 - AP) \quad [2]$$

For a population of a given size N, this can be converted to the estimated number of cases attributed to the exposure, $N_E = I_E * N$.

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

$$I_+(c) = (RR(c) - 1) * p(c) * I_{NE} \quad [3]$$

$$N_+(c) = I_+(c) * N \quad [4]$$

An air pollution baseline for RRs calculations as well as methods of updating RRs have to be defined in conjunction with the Epi, Stats and Exposure AGs.

The impact estimates must be presented as a range. The minimum interval is the one based on the limits of confidence interval of RR used in the analysis (as done in AirQ). If other sources of uncertainty are identified, the procedure can be also applied after appropriate change of input parameters. This can be treated as a part of sensitivity analysis.

If the impact estimate for one health outcome in a population group (e.g. hospital admission for respiratory disease in children) is calculated using the data on exposure to several components of air pollution, only one estimate should be used for reporting. The preferred estimate will be that with a smallest range emerging from sensitivity analysis. Unless there are reasons to suspect that one of the pollutants acts as an indicator for the other component, the reporting should emphasise that the effects are due to a mixture of pollutants.

If an attempt is made to extrapolate the HIA to other cities, the assumption is that population distribution of air pollution exposure is similar to the one in the cities with data (example: WHO analysis of ca. 100 European cities with air quality data, extrapolated to all cities in Europe west of Urals)[5].

4.3.7. Dissemination of results

Proper discussion of uncertainty of the analysis must be included in the reporting and sensitivity analysis should be used as a guide identifying key determinants of the uncertainty.

Tables

Table 3: **Incidence and relative risk estimates of 24-h mean particulate matter for various health endpoints. (WHO default values in AirQ, December 2000)**

HEALTH ENDPOINT	Incidence	TSP			PM_{10}			$PM_{2.5}$			BS		
	Per 100000	RR	Ref.	RRS	RR	Ref.	RRS	RR	Ref.	RRS	RR	Ref.	RRS
MORTALITY													
Total Mortality	1013	**1.003** (1.002-1.007)	**[14]**	**2**	**1.0074** (1.0062-1.0086)	**[6]**	**3**	**1.015** (1.011-1.019)	**[6]**	**3**	**1.0026** (1.0018-1.0034)	**[7]**	**3**
Cardiovascular Mortality	497	**1.002** (1-1.006)	**[17]**	**1***	**1.008** (1.005-1.018)	**[14]**	**2**				**1.004** (1.002-1.008)	**[17]**	**2***
Respiratory Mortality	66	**1.008** (1.004-1.018)	**[14]**	**1**	**1.012** (1.008-1.037)	**[14]**	**2**				**1.008** (1.004-1.014)	**[17]**	**2***
MORBIDITY													
Hospital Admissions Respiratory Disease	1260				**1.008** (1.0048-1.0112)	**[6]**	**3**						
Hospital Admissions Respiratory Dis <15 Years	100												
Hospital Admissions Respiratory Dis 15-64 Years	66										**1.0056** (1.0012-1.0102)	**[10]**	**3**
Hospital Admissions Respiratory Dis 65+ Years											**1.004** (1-1.0092)	**[10]**	**3**
Hospital Admissions Asthma <15 Years	100										**1.006** (1-1.017)	**[9]**	**1**
Hospital Admissions Asthma >15-64 Years	66										**1.0042** (1-1.0118)	**[9]**	**1**

* Estimation based only on Western European cities

Value of Relative Risk Strength

(RRS):	**1**	**Weak**
	2	**Medium**
	3	**Good**

Table 3: **Continued**

HEALTH ENDPOINT	Incidence	TSP			PM_{10}			$PM_{2.5}$			BS		
	Per 100000	RR	Ref.	RRS	RR	Ref.	RRS	RR	Ref.	RRS	RR	Ref.	RRS
MORBIDITY													
Hospital Admissions COPD	101.4	**1.0044** (1-1.0094)	**[11]**	**1**							**1.007** (1.002-1.012)	**[11]**	**2**
Hospital Admissions Cardiovascular Disease	436				**1.009** (1.006-1.013)	**[13]**	**3**						
Hospital Admissions Congestive Heart Elderly	122												
Acute Myocardial Infarction	132										**1.020** (1.0061-1.0352)	**[18]**	**2**
Chronic Bronchitis													
Chronic Bronchitis >25 Years													
Acute Bronchitis < 15 Years													
Asthma Attacks Children					**1.051** (1.047-1.055)	**[14]**	**2**						
Asthma Attacks Adults					**1.004** (1-1.008)	**[14]**	**2**						

Value of Relative Risk Strength

(RRS): **1** **Weak**

2 **Medium**

3 **Good**

Table 4: **Incidence and relative risk estimates of SO_2, NO_2 and ozone for various health endpoints. (WHO default values in AirQ, December 2000)**

HEALTH ENDPOINT	Incidence	SO_2			NO_2 daily avg			NO_2 1 hr max			O_3 1 hr max		
	Per 100000	RR	Ref.	RRS	RR	Ref.	RRS	RR	Ref.	RRS	RR	Ref.	RRS
MORTALITY													
Total Mortality	1013	**1.004** (1.003-1.0048)	**[7]**	**2**				**1.003** (1.0018-1.0034)	**[8]**	**2**	**1.0046** (1.0028-1.0066)	**[8]**	**3**
Cardiovascular Mortality	497	**1.008** (1.002-1.012)	**[17]**	**1**	**1.002** (1-1.004)	**[12]**	**2**	**1.002** (1-1.002)	**[17]**	**2**	**1.004** (1.002-1.006)	**[17]**	**2**
Respiratory Mortality	66	**1.01** (1.006-1.014)	**[17]**	**1**							**1.008** (1.004 -1.012)		**2**
MORBIDITY													
Hospital Admissions Respiratory Disease	1260												
Hospital Admissions Respiratory Dis <15 Years	100												
Hospital Admissions Respiratory Dis 15-64 Years	66	**1.0018** (1-1.005)	**[10]**	**3**	**1.002** (1-1.0072)	**[5]**	**1**	**1.0008** (1-1.0022)	**[10]**	**1**	**1.0038** (1.001-1.0066)	**[10]**	**2**
Hospital Admissions Respiratory Dis 65+ Years		**1.004** (1.001-1.009)	**[10]**	**3**	**1.0038** (1-1.012)	**[5]**	**1**	**1.0010** (1-1.00266)	**[10]**	**1**	**1.0062** (1.003-1.0094)	**[10]**	**2**
Hospital Admissions Asthma <15 Years	100	**1.015** (1.0052-1.025)	**[9]**	**1**	**1.0052** (1.0012-1.0098)	**[4]**	**1**	**1.0024** (1-1.005)	**[9]**	**1**	**1.0012** (1-1.0074)	**[9]**	**1**
Hospital Admissions Asthma >15-64 Years	66	**1** (1-1.0068)	**[9]**	**1**	**1.0058** (1.0006-1.011)	**[4]**	**1**	**1.0022** (1-1.0044)	**[9]**	**1**	**1.003** (1-1.0156)	**[9]**	**1**

Value of Relative Risk Strength (RRS):

1 Weak
2 Medium
3 Good

Table 4: **Continued**

HEALTH ENDPOINT	Incidence	SO_2			NO_2 daily avg			NO_2 1 hr max			O_3 1 hr max		
	Per 100000	RR	Ref.	RRS	RR	Ref.	RRS	RR	Ref.	RRS	RR	Ref.	RRS
MORBIDITY													
Hospital Admissions COPD	101.4	**1.0044** (1-1.011)	**[11]**	**1**	**1.0038** (1.0004-1.0094)	**[6]**	**2**	**1.0026** (1.0006-1.0044)	**[11]**	**2**	**1.0058** (1.0022-1.0094)	**[11]**	**2**
Hospital Admissions	436												
Cardiovascular Disease													
Hospital Admissions Congestive Heart Elderly	122												
Acute Myocardial Infarction	132	**1.0064** (1.0026-1.0101)	**[18]**	**2**	**1.0036** (1.0015-1.0084)	**[18]**	**1**						
Chronic Bronchitis													
Chronic Bronchitis >25 Years													
Acute Bronchitis < 15 Years													
Asthma Attacks Children													
Asthma Attacks Adults													

Value of Relative Risk Strength (RRS):

1 Weak
2 Medium
3 Good

Table 5: **Incidence and relative risk estimates of ozone, CO and long-term PM for various health endpoints. (WHO default values in AirQ, December 2000)**

HEALTH ENDPOINT	Incidence	O_3 8 hr max			CO (per 10 mg/m3)			PM_{10} Long-term (annual averages)			PM2,5 Long-term (annual averages)		
	Per 100000	RR	Ref.	RRS	RR	Ref.	RRS	RR	Ref.	RRS	RR	Ref.	RRS
MORTALITY													
Total Mortality	1013	**1.0051** (1.00023-1.0078)	**[16]**	**1**	**1.1** (1.05-1.15)	**[12]**	**1**	**1.1** (1.03-1.18)	**[6]**	**3**	**1.14** (1.04-1.24)	**[6]**	**3**
Cardiovascular Mortality	497	**1.004** (1-1.006)	**[17]**	**2**									
Respiratory Mortality	66	**1.0125** (1.0046-1.0208)	**[16]**	**2**									
MORBIDITY													
Hospital Admissions Respiratory Diseases	1260												
Hospital Admissions Respiratory Dis <15 Years	100												
Hospital Admissions Respiratory Dis 15-64 Years	66	**1.0062** (1.0026-1.0098)	**[10]**	**2**									
Hospital Admissions Respiratory Dis 65+ Years		**1.0076** (1.0036-1.0116)	**[10]**	**2**									
Hospital Admissions Asthma <15 Years	100	**1** (1-1.0076)	**[9]**	**1**									
Hospital Admissions Asthma >15-64 Years	66	**1.007** (1-1.0288)	**[9]**	**1**									

Value of Relative Risk Strength (RRS):

1 Weak
2 Medium
3 Good

Table 5: **Continued**

HEALTH ENDPOINT	Incidence	O_3 8 hr max			CO (per 10 mg/m3)			PM_{10} Long-term (annual averages)			PM2,5 Long-term (annual averages)		
	Per 100000	RR	Ref.	RRS	RR	Ref.	RRS	RR	Ref.	RRS	RR	Ref.	RRS
MORBIDITY													
Hospital Admissions COPD	101.4	**1.0086** (1.0044-1.013)	**[11]**	**2**									
Hospital Admissions	436												
Cardiovascular Disease													
Hospital Admissions Congestive Heart Elderly	122				**1.28** (1.12-1.45)	**[15]**	**2**						
Acute Myocardial Infarction	132				**1.197** (1.069-1.328)	**[18]**	**1**						
Chronic Bronchitis								**1.29** (1-1.83)	**[6]**	**3**	**1.34** (1-1.99)	**[6]**	**3**
Chronic Bronchitis >25 Years								**1.098** (1.009-1.194)	**[13]**	**1**			
Acute Bronchitis < 15 Years								**1.306** (1.135-1.502)	**[13]**	**1**			
Asthma Attacks Children													
Asthma Attacks Adults													

Value of Relative Risk Strength (RRS):

1 Weak

2 Medium

3 Good

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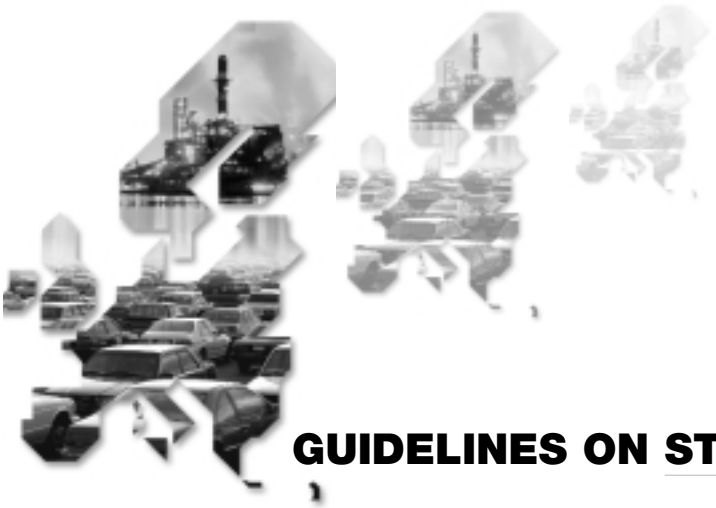

GUIDELINES ON STATISTICS

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5.1. Statistical Modelling of Daily Counts in Individual Cities

5.1.1. Basic Approach

The basic approaches for modelling daily counts of deaths or hospital admissions will be the same, and are summarised below.

1. The data will be assumed to be coming from a non-stationary overdispersed Poisson Process, whose expected value varies with long-term time trends, seasonal patterns, weather, holidays, epidemics, day of the week, any special factors present in each city, and pollution. We anticipate that control for these factors will substantially reduce the overdispersion in the data, but not eliminate it. Therefore overdispersion must be taken into account in estimating standard errors. Lack of improvement in overdispersion by modelling these factors should be taken as an indication of poor modelling, and suggests further efforts to improve the model.
2. The dependence on many of these factors will be nonlinear, and these nonlinearities must be taken into account in the modelling. We recommend Generalised Additive Models[1], which are available in Splus software, among others. For specificity, some of our recommendations will refer to options or commands specific to Splus. Specifically, we recommend locally weighted nonparametric smoothing for the control of these nonlinear factors.

This is for the following reasons:

   a. Compared to global nonlinear fits (e.g. polynomials) these allow a more local fit. Hence the, for example, data on very low temperature days do not influence the fit at very hot days. While polynomial splines can do the same thing, the nonparametric smooths are somewhat more flexible.
   b. Flexibility is particularly important for modelling season. The seasonal patterns can vary quite locally. For example, in 10 years of data the winter peaks in pneumonia hospital admissions can vary considerably from year to year in both height (how bad was the epidemic), location (what week of winter saw the peak), and shape (single versus double peak). Nonparametric smoothing is particularly able to fit such patterns, while not at the same time overfitting the model the rest of the year.

3. Both weather and air pollution are expected to have effects on the outcomes that persist for more than 24 hours. Hence the outcomes should be examined as a function of these predictors on the same and on previous days. The effects of epidemics on mortality may also persist, so models should examine whether mortality remains elevated for a day or two after the end of an influenza epidemic, for example. These models can involve for example into two day moving averages, but a quadratic distributed lag model out to lag 4 or 5 will likely be more informative for air pollution. Different lags should be expected for different outcomes. For example the lag between exposure and a myocardial infarction death (or admission) is likely to be different from the lag between exposure and a pneumonia death (or admission).
4. One major source of overdispersion is heterogeneity in the population. Where the sample size permits, separate models by age, or for respiratory versus cardiovascular events, may help reduce overdispersion and give better control for season.

5.1.2. Variables to be considered

1. All of the routinely measured air pollution variables should be collected and examined. For **weather variables**, temperature, humidity, and barometric pressure have been shown to be predictive of both daily deaths and hospital admissions for heart and lung disease. Minimum

temperature has usually been found to be a slightly better predictor than mean temperature. Dew point temperature is more independent of temperature than relative humidity, and is probably more physiologically relevant as well.

2. It is difficult to control for **respiratory epidemics** with the seasonal model without risking overfitting in non-epidemic periods. This is because even with local smoothing, the same span (loess) or degrees of freedom per year (cubic smoothing spline) is used to model the entire season. Control for respiratory epidemics is seen to be not merely a question of potential confounding, but of successfully modelling season. Possible sources of data are sentinel monitoring of influenza visits, pneumonia hospital admissions, and respiratory mortality. Whichever information is available, it would be better to identify specific epidemic periods with that information, and then put in separate smooth terms (or splines or polynomials) to capture the effect on mortality in that period where much more than normal seasonal variations are going on. A simple dummy variable approach assumes the same increase in daily events in each day of each epidemic in each year. This is a fairly crude approach.
3. The same issue applies to **holidays**. Single day holidays can be adequately dealt with by dummy variables. School holidays may present a larger concern, particularly for hospital visits of children, but also for their parents. Periods where much of the city is likely to be on vacation again represents a sudden drop in the susceptible population, and separate time trend terms to model these periods may be appropriate.
4. **Day of the week variables** will be very important for hospital admissions. For mortality, they will be less important, and a weekend/weekday contrast may suffice. However, this should be demonstrated and not simply assumed.

5.1.3. Detailed Modelling Choices

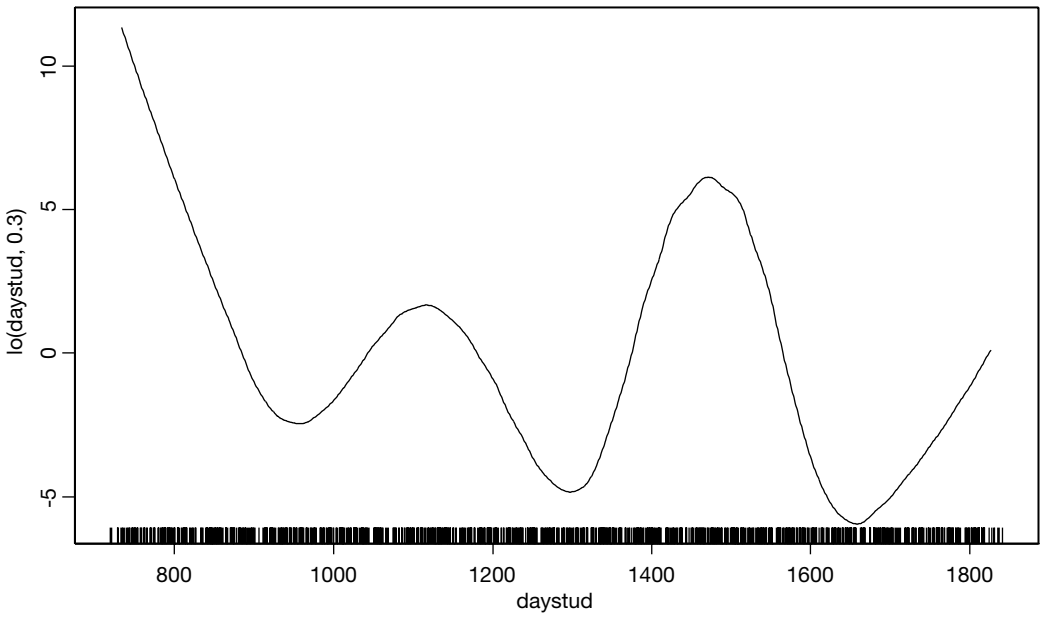
Choice of smoothing parameters

First, it must be recognised that there is no perfect method for choosing smoothing parameters, just as there is no perfect method for variable selection. In the case of generalised additive models where the smoothing parameters must be chosen for multiple variables simultaneously, there is even less guidance from asymptotics than in the linear case. Nevertheless, it is useful to have some nonsubjective method, and we recommend the following. For weather variables, smoothing parameters should be chosen to minimise Akaike's Information Criterion. The choice of how many lags of the weather variables to include may likewise be chosen this way. It should recognised that AIC is slightly biased in favour of including more terms/degrees of freedom. More parsimonious model selection can be achieved by minimising BIC. Another alternative is to use a modified version of AIC as proposed by Hurvich[2].

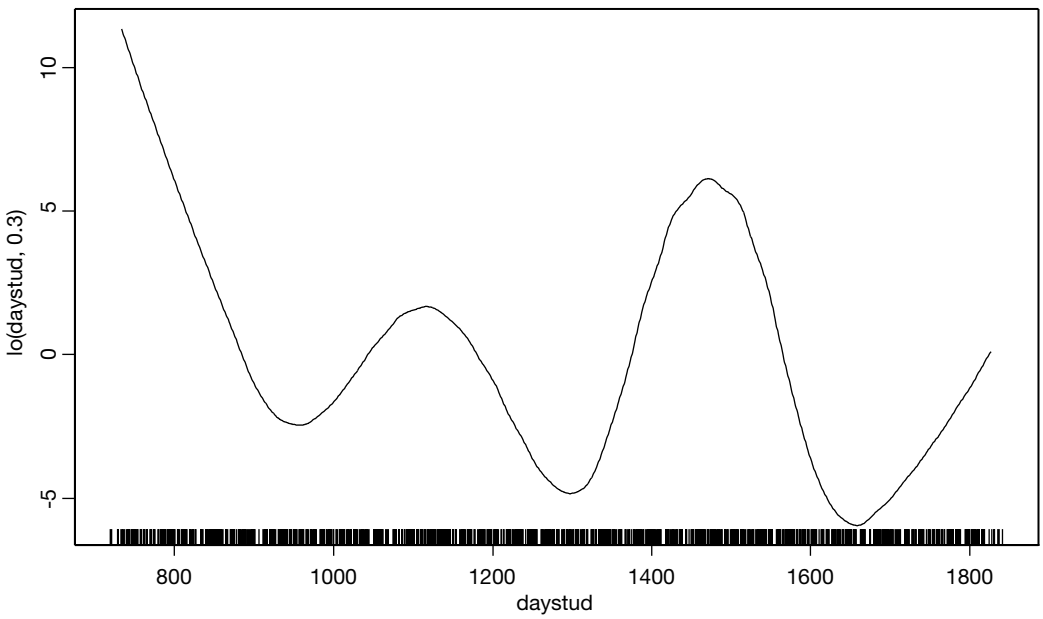
The choice of smoothing parameter for removing long-term time trends and seasonality is more complex. It must be remembered that time is not a causal variable. Rather, we remove long-term time trends and seasonal variations from the event data because omitted covariates that vary seasonally, or have time trends, may confound the association with air pollution. There are other shorter term patterns in event data. For deaths and hospital admissions these are not generally periodic-rather, they represent discrete episodes in time. This is illustrated in the figures below. They show smooth plots of daily deaths in a city for a three-year period. Three years was chosen to better see the pattern within individual years.
The first plot is with a span of 330 days, and despite using fewer than two degrees of freedom per year, captures the seasonal pattern in the data.
The second plot uses a span of 220 days. This corresponds to almost 3 degrees of freedom per year, and captures a bit more structure.
The third figure has a span of 110 days, or 6 degrees of freedom per year (note the increase is not linear in the span). Note that there is now considerable short-term structure. This takes the form of bumps on the larger structure, and some of those bumps are small, and possibly due to air pollution or adverse weather patterns. Further smoothing only accentuates this. Now the problem is that some of the added structure may be due to, for example, epidemics.

Other structure in the last figure (span of 0.05, 12 df per year) may be due to noise, that is overfitting. Or it may be due to the variables we wish to estimate. This is why using separate terms to model the epidemics (or holidays), which allows a larger span to be used capture the general seasonal pattern, will be advantageous.

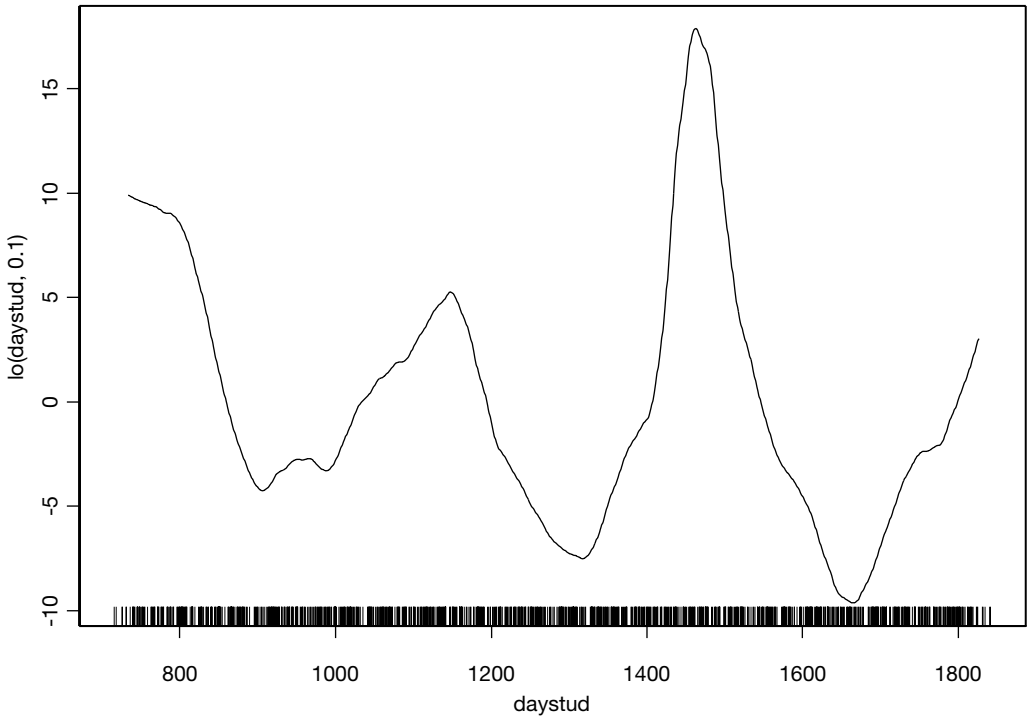
Deviation from mean Daily Deaths with span of 0.3



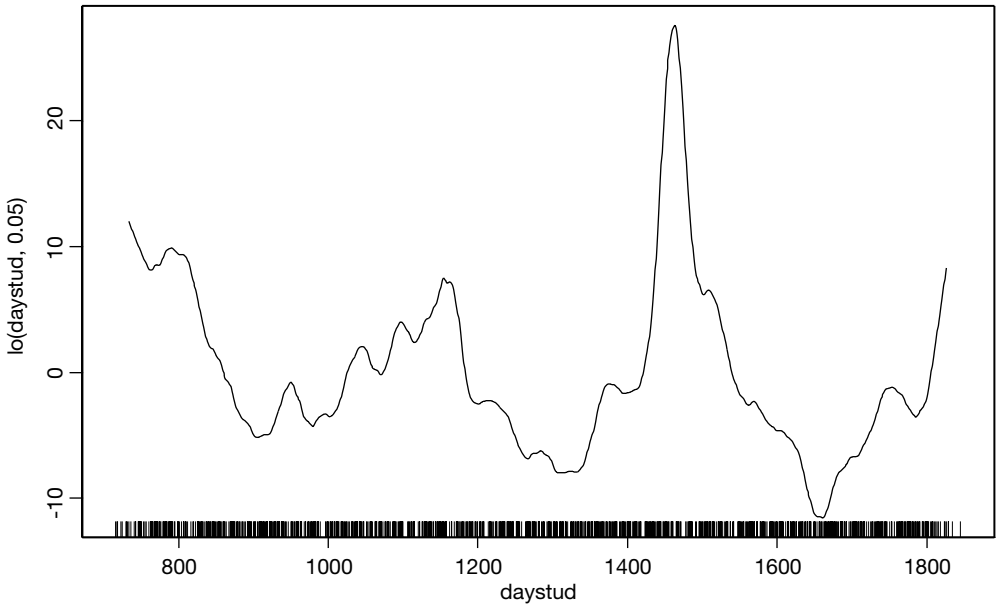
Deviation from mean Daily Deaths with span of 0.2



Deviation from mean Daily Deaths with span of 0.1



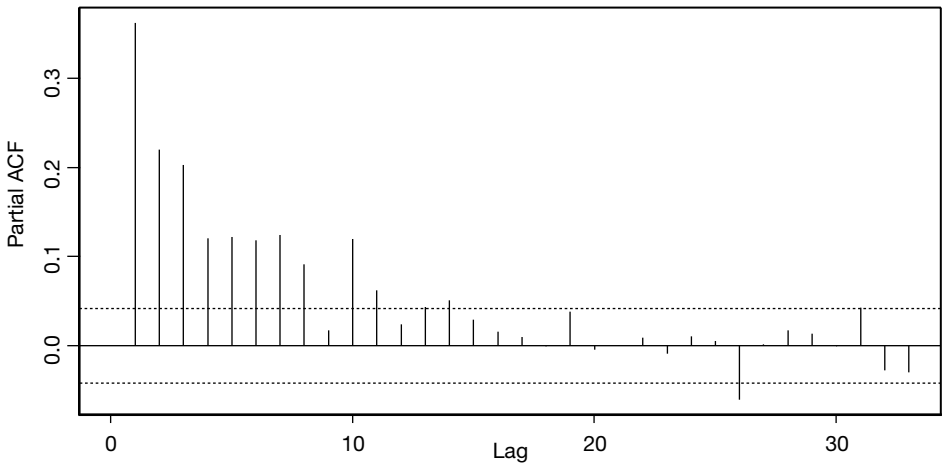
Deviation from mean Daily Deaths with span of 0.05



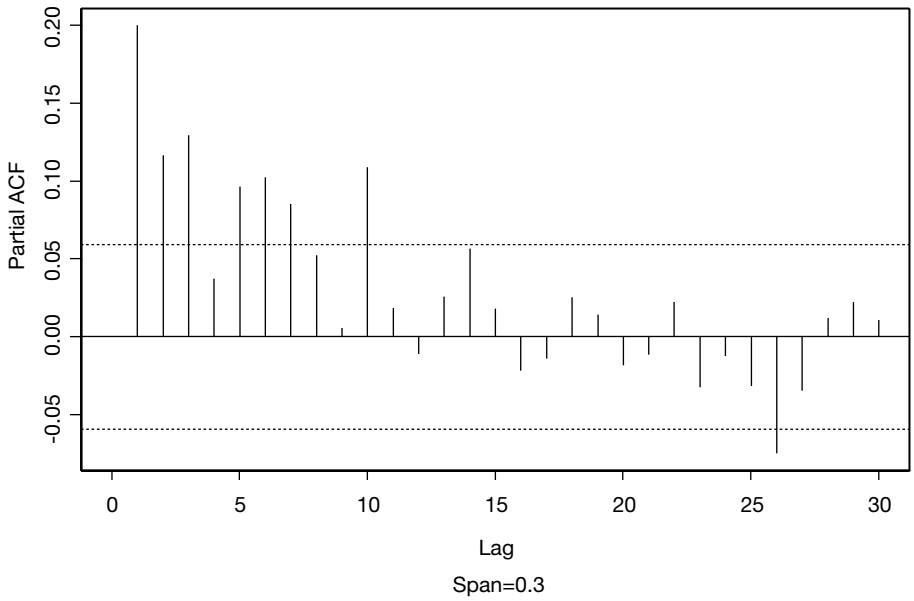
Within the range of spans that meet this objective, we prefer to choose the one that minimises the autocorrelation in the residuals. This has two advantages. First, it avoids the necessity for fitting autoregressive Poisson models. Second, if serial correlation exists in the residuals, this indicates that an omitted covariate had serial correlation. Since the air pollution variables have serial correlation as well, this may confound the pollution association. Minimising this correlation therefore seems a natural goal.

Note too that the amount of smoothing for time that is used can do more than remove the serial correlation that is present. Oversmoothing can also induce serial correlation. To see this, note the partial autocorrelation functions below. The first is for the raw daily death data, and the next four are for the four models shown above.

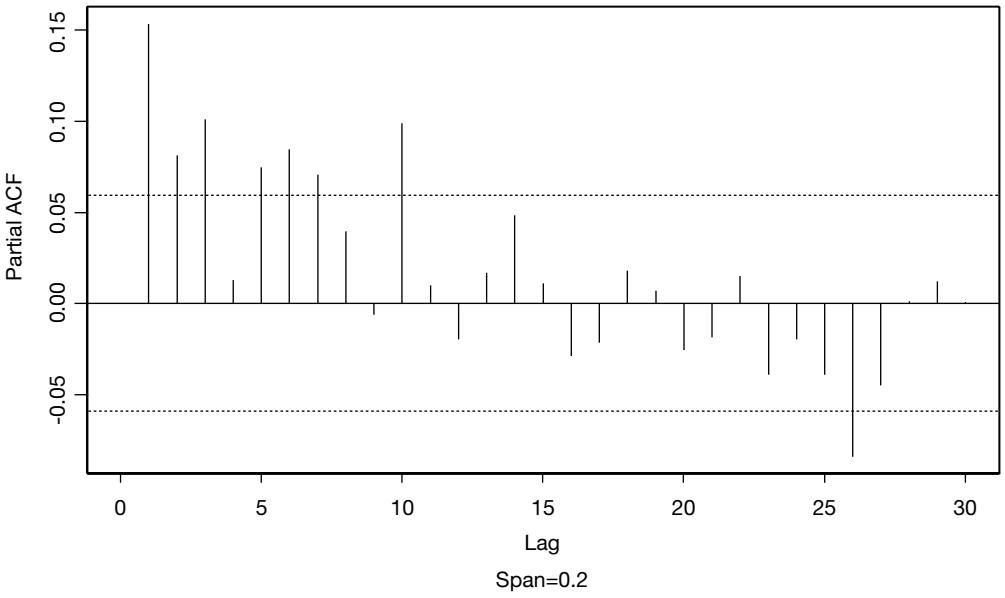
Series: Chicago



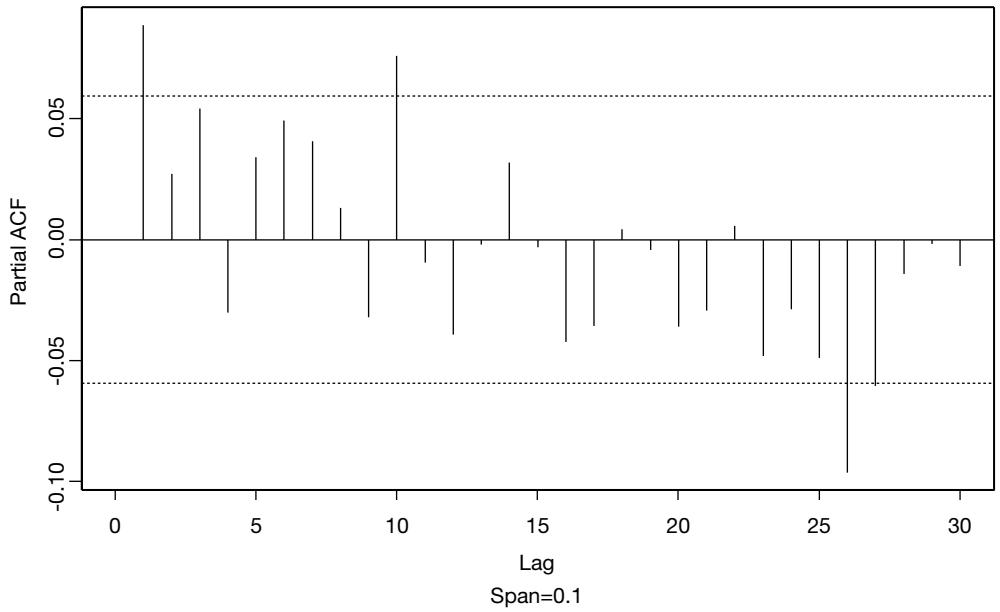
Series: Residuals (look1, type = "deviance")



Series: Residuals (look1, type = "deviance")



Series: Residuals (look1, type = "deviance")



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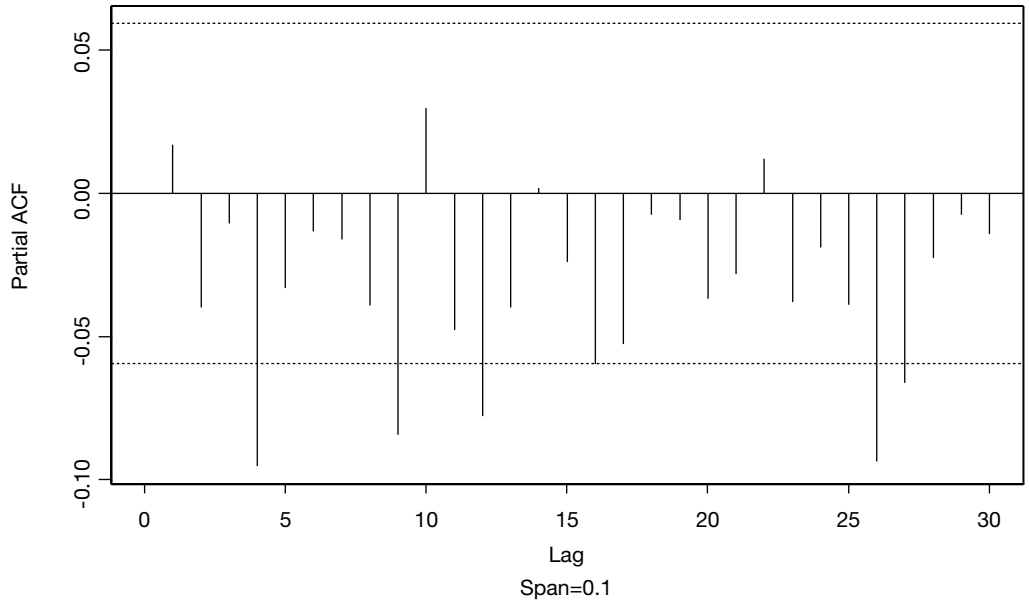

Note that as the span decreases, the substantial autocorrelation also decreases. Note also, however, the negative autocorrelation that was not present in the original data is beginning to be induced, and by the time a span of 0.05 is reached, the correlation at almost every lag is negative. This is clearly dangerous, as the pattern being introduced into the data may interact with air pollution.

5.2. Health Impact Assessment in Individual Cities

5.2.1. Exposure-response relationships

Health impact assessments are a key part of APHEIS, and will be performed in individual cities. The question always arises as to which slope between outcome and pollutant to use, the average of all cities, derived from a meta-analysis of the overall data, or the city specific slope.

It is naïve to assume that the city specific slope is better, because it is derived from the city of interest. The situation is more complex. If for the specific outcome and pollutant of interest, there is no evidence of heterogeneity, then we must conclude that the variations of city specific slopes about the overall mean is purely stochastic. In that case, the population mean slope should be used.

Often, heterogeneity will be present. This still does not mean that the city specific slope is the best estimate, however. In the case where heterogeneity is present, slope estimates vary about the population mean slope for two reasons. One is true heterogeneity in the slopes, and the other is still stochastic error. We would like a city specific estimate that reflects the first source of variation, but not the second. This is obtainable by using a shrunken estimate derived as follows.

First, fit a random effects meta-analysis, using the method of Berkey[3]. That is, we assume for each city i we have

$$\hat{\beta}_i \sim N(\beta_i, V_i)$$

where β_i is the true slope in town i.

We also assume that the true slopes are also normally distributed about the population mean slope

$$\beta_i \sim N(\beta, \delta) \quad \text{and hence} \quad \hat{\beta}_i < \sim N(\beta, V_i + \delta)$$

Then, to obtain a shrunken estimate of β_i, obtain the maximum likelihood estimates of β and δ using the function provided by Evi Samoli. Then obtain the shrunken estimate (that is, eliminating V_i as a source of variation, but keeping δ) as

$$\beta_{i_{shr}} = \delta Z_i + \hat{\beta}$$

where

$$Z_i = (\beta_i - \beta)/(V_i + \delta)$$

5.2.2. Calculating the attributable number of cases

After defining which estimate should be used for health impact assessment, we need to define formula to calculate the attributable number of cases. This will be done in collaboration with the HIA group, and will be concretised after the workshop organised with WHO-ECEH in June 2001.

5.2.3. Comparing different time periods

Comparing Relative Risk obtained for different time periods are also a key part of APHEIS. The goal of this project is to help regulation by regularly reassessing health impact of air pollution on health.

One way is to regularly rerun analysis on a subset of cities and compare the risks between each period. If we simply use this naive approach, we make a strong hypothesis, that the populations in each city are exactly comparable between each period. For example, if the population is older in the second period than in the first, the RR could be higher. By the way, we could not be able to know which part in the change in the RR is due to a different population or a different mixture of air pollution.

A better approach would be to use the multiple time periods, combined with the multiple cities in APHEIS, to enable a hierarchical model. That is, we can regress the coefficient we find in each city and time period against characteristics of the population, or of the pollution mix, in a meta-regression. This offers the possibility to understand the causes of the differences, and not merely their presence. In addition, it makes better use of the data. Differences between time periods in individual cities will be hard to distinguish from stochastic variability. Combining all cities to look at period to period differences, however, risks missing real changes, if they only occur in some of the cities. The regression approach can combine information across cities while recognising that the changes in populations, exposure mixes, or exposure patterns, may not be the same in each city. For this to work well, however, we will need to gather that information. Population data is easily obtainable, but source apportionment studies, estimates of air-conditioning use in offices and homes (which substantially modifies exposure), etc need to be encouraged.

Another way is to run the analysis on a longer time period, covering the 2 periods of interest. To detect changes in the effect of air pollution, we could add an interaction between pollutant and a dummy variable representing time period. With time series, factors that slowly vary across time can confound the association. For example, if the population become older and older, a bigger part is susceptible to die. This long-term trend is taken into account in the analysis. Yet, this factor may interact with the degree of the association with air pollution: older is the population, higher could be the risk relative to the general population. By the way, the dummy variable could play as a proxy for change in the population.

These different possibilities should be tested in some voluntary centres before using it for all the APHEIS centres. Nevertheless, further work is needed to ensure comparability between time period of the effect of air pollution.

5.3. Who analyses the data?

As we can see, the statistical issues in the APHEIS programme are quite complex. Time series analysis requires experienced statisticians, adequate statistical resources and prior training and support from the centres with experiences in these methods.

Calculations for HIA can be done in each centre after training to use the AirQ software for health-impact assessment developed by WHO.

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Part II – Feasibility of an epidemiological surveillance system

FEASIBILITY OF AN EPIDEMIOLOGICAL SURVEILLANCE SYSTEM

6.1. Introduction

The implementation of an information system at the European level is based on the principle of working with local partners to gather and analyse data. This requires the prior assessment in each participating centre of the situation and prospects regarding its feasibility, especially with respect to the institutional and organisational requirements which are needed to successfully pursue such effort. Accordingly, an explicit, long-term commitment will be needed from the participating centres to collaborate in the implementation of the information system.

The present chapter covers the description of the objectives which were formulated to assess the feasibility of APHEIS in each centre, as well as the methods used and the results obtained, both at the aggregate level and for each site.

The description follows a two-step process: the first step covers aspects related to the local conditions considered to be important organisational factors in the set up of an information system on air pollution and health, while the second step deals with the evaluation of the compliance of the criteria formulated in the guidelines, in each of the five areas, in each participating centre.

The chapter ends with a set of conclusions on the basic requirements for the feasibility of the implementation of APHEIS, as well as the description of the prospects for its implementation, both at the aggregate European level and for each participating centre.

6.2. Objectives

The main objective was to collect relevant information regarding modalities of organisation among participating centres, in order to define future scenarios for testing the feasibility of APHEIS and identify key points for the implementation of APHEIS in participating sites in the second year of the project.

The two specific objectives formulated to assess feasibility dealt with:

a) the interest of the different stakeholders of each city in the proposed surveillance system and how institutions could work together;

b) the availability of the requirements to implement the system. More specifically, the following main areas were considered:

- availability of health and AQ data;
- capabilities for the analysis and interpretation of H & AQ data;
- effective and efficient dissemination;
- models of organisation.

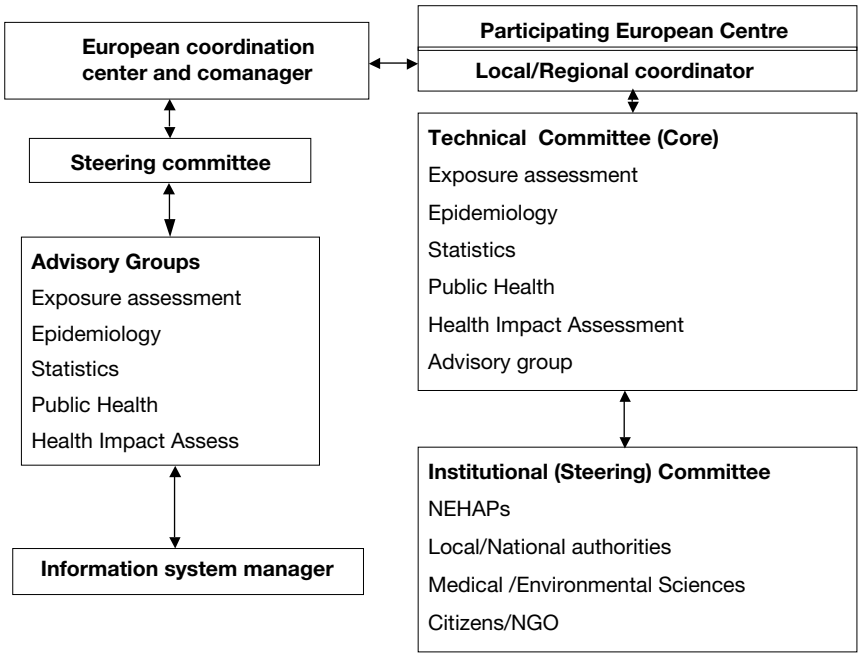
Each of these areas is considered essential to contribute to the closeness between public health and environmental decision-making processes.

An overall basic organisational model for the surveillance system was defined *a priori*, with two main levels (see Figure 1):

– a central coordinating level at the European level, including a Steering Committee, five Advisory groups, and an information system management unit;

– a local level, based on a local coordination unit, a technical committee supported by different advisors, and an Institutional Steering Committee.

Figure 1: **Proposal for a basic organisational model for APHEIS. Central and local levels.**



6.3. Methods

6.3.1. Phase 1: Local set-up description

A questionnaire was designed by the research team to collect, in each centre, information regarding some of the characteristics considered to be key aspects of the local set-up conditions needed to support a favourable development of APHEIS. These characteristics included information on:

- Coordinator/Institution identification
- Linkage of centre with national/regional networks
- Scenario/levels of collaboration between data providers and those in charge of surveillance system
- Regulations on AQ: existence, activities, organisations in charge
- Public Health: activities, organisations in charge
- Sociodemographic data: activities, organisations in charge
- Meteorological data: activities, organisations in charge
- Established framework of collaboration between Environmental and Health organisations (type/level)
- Existence of a social/grass-roots framework/participation
- Willingness to collaborate (agency-specific)
- Data availability/analysis/dissemination
- Human resources requirements/availability (by activity)
- Structural resources requirements/availability (by type)
- Potential financing sources
- Potential users of information (by type/level)
- Potential partners for Technical Committee (by type)
- Potential partners for Institutional Committee (by type)
- Need for a pre-launching site visit

This questionnaire was completed by local coordinators with the contribution, in some instances, of other local professionals involved in areas covered by the questionnaire.

The data collection phase was carried out from March to May 2000. The data were then processed and analysed in June 2000, and presented and discussed at the Project meeting in Ispra, in June 2000.

6.3.2. Phase 2: Compliance with Guidelines

The purpose of this second phase was to document how far from the guidelines put forward by the advisory groups was the situation in each particular site, that is, what the current situation is regarding the compliance of the guidelines criteria.

In each centre, information was gathered on the situation and prospects regarding:

• availability of data sources:

– environmental
– meteorological
– sociodemographic
– mortality
– hospital admission

• availability of exposure data:

– core set of indicators
– optional indicators

• availability of health data:

– daily mortality
– daily hospital admissions (core/optional)

• availability of data on confounders:

– on short-term relationships (core/optional)
– on long-term relationships (core/optional)

• availability of data on effect modifiers:

– air pollution mix; climate; health status, etc.

• data analyses capabilities

The data collection phase was carried out from July to September 2000. The data were then processed and analysed in October 2000, and presented and discussed at the Project meeting in Barcelona, in October 2000.

6.3.3. Analysis

Data were analysed with a descriptive approach, both for all the centres combined, as well as for each centre. Summary tables and figures were obtained (see section 6.4.).

6.4. Results

6.4.1. Phase 1: Local set up description

The local set up questionnaire was answered by 14 local co-ordinators (88% of centres) of 10 European countries (83% of participating countries). Nine of the cities involved are from France (Bordeaux, Le Havre, Lille, Lyon, Marseille, Paris, Toulouse, Strasbourg, Rouen), five from Spain (Barcelona, Madrid, Seville, Bilbao and Valencia), and the rest from Italy (Rome), Israel (Tel-Aviv), Ireland (Dublin), UK (London), Hungary (Budapest), Romania (Bucharest), Slovenia (Ljubljana and Celje), Sweden (Stockholm and Gotheborg). Athens (Greece) and Cracow (Poland) could not answer the questionnaire.

• Types of participating centres

In six cases, the co-ordinating centre belongs to a regional administration, in four cases it is a university or a research centre, in two it is a local public health institution and in two cases it is a national public health centre. Eight out of the 14 participating centres are linked to national or regional networks of cities. In most cases only one city participates in the programme, except for France with 9 cities, and Slovenia and Sweden with 2 participating cities. Although there are five Spanish cities in the project, each one has its own co-ordinating centre.

• Organisational scenario

Besides answers to the first questionnaire, in the last meeting in Budapest, three main groups of scenarios where distinguished:

– "broad implementation of the APHEIS centre with decision-making contacts": Barcelona, Cracow, Slovenia, Sweden, Budapest and France.

– "data collection and simple implementation of the APHEIS centre, later contact with decision-makers" Rome, Bucharest, Madrid, Sevilla, Valencia, London.

– "data collection, no public health contact": Dublin, Athens.

• Organisations responsible for the different data sources

In table 1, the frequencies of the different levels of administration responsible for the data sources to be integrated in the information system are presented. Whereas local administrations are responsible for air data management in most cases, the situation for health and socio-demographic data is more heterogeneous. Meteorological data are in most cases collected at the national level.

Table 1: **Organisations responsible for the different data sources (*)**

	Local	Regional	National	Local+regional	Local+national
1. Air					
Data collection	7	2	2	2	
Analysis	7	2	2	2	
Dissemination	5	2	2	3	
Compliance	5		3	4	
2. Health					
Data collection	3	2	4	2	2
Analysis	4	2	3	2	2
Surveillance	4	2	3	2	1
Dissemination	4	2	4	2	1
3. Socio-demographic					
Data collection	2	2	4	2	3
Analysis	3	3	3	1	2
Dissemination	3	3	3	1	1
4. Meteorological					
Data collection			10	1	2
Analysis			10	1	1
Dissemination			11	1	

(*) total row counts might not sum up in the case of information not provided for specific variables by some centres.

• Framework of collaboration between organisations

Except for London, in all the participating cities there is some type of established framework of collaboration between Environmental and Health organisations for shared relevant programmes. In three cases, they involve both technical and institutional collaborations at the local level, whereas in four cases the collaboration is either at the technical or at the institutional level. An established collaboration at both the technical and institutional levels of the regional level exists in two cases, whereas in four centres the collaboration is only at the institutional or at the technical level. Finally, there is an institutional and technical collaboration at the national level in one case, and either institutional or technical collaboration at the same level in three cases.

In five APHEIS centres the collaboration between environmental and health organisations is located only at one administrative level, in two cases at two levels (Seville and Rome) and in other two at three (Valencia and Romania).

The situation regarding the involvement of different institutions in data availability, analysis and dissemination is heterogeneous (Table 2).

Table 2: **Institutions responsible for data and analysis in the APHEIS centres (*)**

	Air pollution data agency	Health data agency (or agencies)	Sociodemographic agency (or agencies)	Meteorological agency	Co-ordinating Centre
Data availablity:					
Air pollution data	13	1			1 (additional)
Health data	1	13			
Sociodemographic data		1	13		1 (additional)
Meteorological data		1		12	1 (additional)
Analysis: Building daily indicators on					
Air pollution data	7	1			6
Health data		6			6 (additional)
Sociodemographic data		1	5	1	7 (additional)
Meteorological data		1	5	6	7 (additional)
Local statistical analysis		1			13
Participating in the meta-analysis		1			13

(*) total row counts might not sum up in the case of information not provided for specific variables by some centres.

Regarding the dissemination strategies, in three centres (Slovenia, Ireland and England) the five agencies will be involved; in Romania, Tel-Aviv and Bilbao (air quality, health and coordinating centres) 3 centres are expected to be involved; in Madrid and Barcelona two centres (air quality and the coordinating centres); and in Valencia and Rome only the coordinating centre.

• Human and infrastructure resources

Table 3 presents a summary of the human resources in centres. Only London does not have a coordinator, whereas a majority of centres report some type of expertise in areas of data management, environmental epidemiology, exposure assessment and statistical analysis, mostly in internal positions. The availability of communication experts is less frequent.

Table 3: **Human resources available in the APHEIS centres**

	Availability	
	Internal	Advisor
Co-ordinator of the system	13	
Data manager	11	
Environmental epidemiologist	11	2
Environmental statistician	7	3
Exposure assessment expert	9	2
Communication strategies expert	4	3

Table 4 describes the structural resources available in the APHEIS centres. Two centres have four statistical packages, three have three, six have two and one has only one.

Table 4: **Structural resources available in the APHEIS centres**

	Availability
Computers	14
Photocopier	14
Access to Internet	12
Personnel:	
• Secretary	10
• Web page designer	6
Own Web site	12
Statistic package (type)	8 S-plus, 5 SAS, 8SPSS, 6 STATA, 1BMDP

• Potential users of the information

The potential users of the information provided by APHEIS are summarised in Table 5.

Table 5: **Potential users of the information provided by APHEIS**

	A	B	C	D	E	F	G
Decision markers							
Authorities involved in air quality management	4		1	3	1		4
Authorities involved in public health management	2	2		1	1	4	3
Authorities involved in health services management	3	2		1		4	
Authorities involved in urban planning management	5		1	1	1	3	
NEHAPS	1					1	1
Others (to be identified)							
Professionals (researchers)							
Universities	1		1	1	1		2
Public health researchers	2	3			1	1	3
Health services researchers	2	2			1		8
Clinical researchers	3		1		1		2
Environmental researchers	1	1	1		1		4
Air pollution networks	2	2	1	1	1		3
Economists	1				1		2
Others (to be identified)	4				1	1	
Citizen associations:							
Political parties	4					1	2
Ecologists	4					1	1
Neighbour associations	4		1				1
Unions	2		1				
Schools	5						
Others (to be identified)							

A=local, B=regional; C=national; D=local+regional; E=regional+national; F=local+regional+national; G=local+national

• Financial sources

Most centres (5) have only one financial source, four have 2, four have 3 and one has four. The most common financing sources are national authorities (8), followed by local authorities and public health services 6, regional authorities (4) and environmental agencies (3).

• Potential partners

The potential partners identified for the Technical committee are in order of frequency: exposure assessment experts (12), public health professionals (11), epidemiologists (10) and statisticians and health impact assessment experts (8).

The potential partners identified for the Institutional committee are local authorities (11), regional authorities (9), environmental agencies (8), public health agencies (7), national authorities (6), air pollution networks (5), medical researches (5), environmental researchers (4) and NEHAPS (3).

• Need for a pre-launching visit

Only three centres consider necessary a visit of one coordinator before launching the project.

6.4.2. Phase 2: Compliance with Guidelines

Data were collected for 24 different cities, here referred to as centres (see Figure 2): Valencia, Seville, Madrid, Bilbao, Barcelona (Spain), Cracow (Poland), London (UK), Ljubljana, Celje, (Slovenia), Budapest (Hungary), Rome (Italy), Sweden (although both Gotheborg and Stockholm participate, we only have information on environmental data from Stockholm), Tel-Aviv (Israel), Bucharest (Romania), Bordeaux, Le Havre, Lille, Lyon, Marseille, Paris, Toulouse, Strasbourg, Rouen (France) and Dublin (Ireland). No information could be collected for Athens (Greece).

• Type of Institutions of the APHEIS centres

Most APHEIS centres (75%) are public health institutions. In six cases - Dublin, London, Seville, Sweden, Tel-Aviv and Valencia - the APHEIS centre is an academic institution (Table 6).

Table 6: **Types of Institutions of the APHEIS centres**

	City	Type of institution
1.	Barcelona	Public Health Institute
2.	Bilbao	Public Health Direction
3.	Bordeaux	Public Health Institute
4.	Bucharest	Institute of Public Health
5.	Budapest	Public Health Centre/Environmental Health
6.	Celje	Institute of Public Health
7.	*Dublin*	*Dublin University*
8.	Cracow	Regional Sanitary Inspection
9.	Le Havre	Public Health Institute
10.	Lille	Public Health Institute
11.	*London*	*Medical School*
12.	Lyon	Public Health Institute
13.	Madrid	Regional Public Health Authority
14.	Ljubljana	Institute of Public Health
15.	Marseille	Public Health Institute
16.	Paris	Public Health Institute
17.	Rome	Agency for Public Health
18.	Rouen	Public Health Institute
19.	*Seville*	*School of Public Health*
20.	*Stockholm/Gotheborg*	*Umea University*
21.	Strasbourg	Public Health Institute
22.	*Tel-Aviv*	*Tel-Aviv University*
23.	Toulouse	Public Health Institute
24.	*Valencia*	*School of Public Health*

In italic cities where the coordinating centres are academic institutions.

• Data collection

The APHEIS centre routinely collects the air quality data in 7 cases, the meteorological data in 5, the sociodemographic data in 2, the mortality data in 3 and the hospital admissions data in 4. When data are not collected at the APHEIS centre difficulties for getting an agreement of collaboration with the agency responsible for the data are foreseen in one case (Bucharest) for meteorological data, one for sociodemographic data (Poland), and one for hospital admissions data (Lyon).

• Exposure data

Most centres have routine sources for collecting the set of core air quality indicators as shown in Table 7.

Table 7: **Number of centres with routine source of the core set of indicators**

Air quality indicator	Number of cities
1. PM_{10} (24 hours average)	22
2. Sulphur dioxide (24 hours average)	23
3. Nitrogen dioxide (24 hours average)	24
4. Carbon monoxide: maximum 8-hour average	20
5. Ozone: maximum 8 hours	22
6. Ozone: maximum 1 hour daily value	22

The number of monitoring stations differs between centres as shown in the next tables.

Almost all centres collect data on PM_{10} (Table 8), with a wide range in the total number of stations by centre (from 1 to 34), as a well as a varying balance between the relative contribution of types of monitoring stations by centre, although the largest number is distributed between background and traffic monitoring stations.

Table 8: **Monitoring stations of PM_{10}**

	Number of background monitoring stations	Number of traffic monitoring stations	Number of industrial monitoring stations	Total
Barcelona	1	2	0	3
Bilbao	0	0	0	0
Bordeaux	4	3	0	7
Bucharest	2	4	3	9
Budapest	2	4	2	8
Celje	0	1	0	1
Dublin	1	3	0	4
Cracow	3	1	1	5
Le Havre	0	0	0	0
Lille	3	1	3	7
Ljubljana	1	0	0	1
London	6	5	0	11
Lyon	1	5	0	6
Madrid	10	24	0	34
Marseille	3	1	0	4
Paris	9	1	0	10
Rome	1	3	0	4
Rouen	1	0	0	1
Seville	1	7	0	8
Stockholm	1	1	0	2
Strasbourg	3	2	0	5
Tel-Aviv	3	0	0	3
Toulouse	3	0	0	3
Valencia	0	0	1	1

All centres collect data on SO_2 (Table 9) with a wide range in the total number of stations by centre (from 1 to 36), as a well as a varying balance between the relative contribution of types of monitoring stations

by centre, although the largest number is distributed between background and traffic monitoring stations, with the exception of Lyon, which includes a large number of industrial monitoring stations.

Table 9: **Monitoring stations of SO_2**

	Number of background monitoring stations	Number of traffic monitoring stations	Number of industrial monitoring stations	Total
Barcelona	1	3	0	4
Bilbao	2	9	2	13
Bordeaux	4	1	0	5
Bucharest	2	4	3	9
Budapest	2	4	2	8
Celje	0	0	1	1
Dublin	14	0	0	14
Cracow	15	1	1	17
Le Havre	7	0	4	11
Lille	7	1	4	12
Ljubljana	1	1	0	2
London	10	4	0	14
Lyon	16	8	12	36
Madrid	10	24	0	34
Marseille	3	5	0	8
Paris	16	1	2	19
Rome	1	2	0	3
Rouen	7	0	2	9
Seville	0	6	0	6
Stockholm	1	0	0	1
Strasbourg	4	3	2	9
Tel-Aviv	10	0	0	10
Toulouse	1	2	0	3
Valencia	6	12	2	20

All centres collect data on NO_2 (Table 10), with a wide range in the total number of stations by centre (from 1 to 34), as a well as a varying balance between the relative contribution of types of monitoring stations by centre, although the largest number is distributed between background and traffic monitoring stations, with the exception of Lyon, which includes a larger number of industrial monitoring stations.

Table 10: **Monitoring stations of NO_2**

	Number of background monitoring stations	Number of traffic monitoring stations	Number of industrial monitoring stations	Total
Barcelona	1	4	0	5
Bilbao	4	9	4	17
Bordeaux	4	3	0	7
Bucharest	2	4	3	9
Budapest	2	4	2	8
Celje	1	1	0	2
Dublin	0	9	0	9
Cracow	6	1	1	8
Le Havre	3	1	1	5
Lille	9	5	3	17
Ljubljana	2	0	0	2
London	13	10	0	23
Lyon	4	9	5	18
Madrid	10	24	0	34
Marseille	6	4	0	10
Paris	17	8	0	25
Rome	3	7	0	10
Rouen	3	1	1	5
Seville	1	7	0	8
Stockholm	4	2	0	6
Strasbourg	4	2	0	6
Tel-Aviv	5	5	0	10
Toulouse	5	3	2	10
Valencia	1	4	1	6

Twenty centres routinely collect data on CO (Table 11) with a wide range in the total number of stations by centre (from 1 to 34), as a well as a varying balance between the relative contribution of types of monitoring stations by centre, although the largest number is distributed between background and traffic monitoring stations.

Table 11: **Monitoring stations of CO**

	Number of background monitoring stations	Number of traffic monitoring stations	Number of industrial monitoring stations	Total
Barcelona	1	4	0	5
Bilbao	2	6	1	9
Bordeaux	0	3	0	3
Bucharest	0	0	0	0
Budapest	2	4	3	9
Celje	0	0	0	0
Dublin	0	1	0	1
Cracow	3	1	1	5
Le Havre	0	0	0	0
Lille	0	4	0	4
Ljubljana	1	0	0	1
London	9	8	0	17
Lyon	0	4	0	4
Madrid	10	24	0	34
Marseille	0	3	0	3
Paris	0	0	0	0
Rome	3	7	0	10
Rouen	0	1	0	1
Seville	0	7	0	7
Stockholm	2	2	0	4
Strasbourg	0	1	0	1
Tel-Aviv	0	5	0	5
Toulouse	3	0	0	3
Valencia	1	4	1	6

Twenty two centres routinely collect data on O_3 (max-8 h.) (Table 12) with a wide range in the total number of stations by centre (from 1 to 34), as a well as a varying balance between the relative contribution of types of monitoring stations by centre, although the largest number is distributed between background and traffic monitoring stations.

Table 12: **Monitoring stations of ozone (maximum 8 hours)**

	Number of background monitoring stations	Number of traffic monitoring stations	Number of industrial monitoring stations	Total
Barcelona	0	4	0	4
Bilbao	3	5	1	9
Bordeaux	4	0	0	4
Bucharest	0	0	0	0
Budapest	1	1	0	2
Celje	1	0	0	1
Dublin	0	0	0	0
Cracow	1	0	0	1
Le Havre	3	0	0	3
Lille	9	0	0	9
Ljubljana	2	0	0	2
London	14	1	0	15
Lyon	3	1	2	6
Madrid	10	24	0	34
Marseille	5	0	0	5
Paris	10	0	0	10
Rome	2	3	0	5
Rouen	5	0	0	5
Seville	1	2	0	3
Stockholm	1	0	0	1
Strasbourg	4	0	0	4
Tel-Aviv	4	0	0	4
Toulouse	5	0	0	5
Valencia	1	4	1	6

Similarly, 22 centres routinely collect data on O_3 (1 h-daily) (Table 13), with a distribution of the number and type of stations similar to what has been described for O_3 (max-8 h.) in the previous table.

Table 13: **Monitoring stations of ozone, 1 hour daily**

	Number of background monitoring stations	Number of traffic monitoring stations	Number of industrial monitoring stations	Total
Barcelona	0	4	0	4
Bilbao	3	5	1	9
Bordeaux	4	0	0	4
Bucharest	0	0	0	0
Budapest	1	1	0	2
Celje	1	0	0	1
Dublin	0	0	0	0
Cracow	1	0	0	1
Le Havre	3	0	0	3
Lille	9	0	0	9
Ljubljana	2	0	0	2
London	14	1	0	15
Lyon	3	1	2	6
Madrid	10	24	0	34
Marseille	5	0	0	5
Paris	10	0	0	10
Rome	2	3	0	5
Rouen	5	0	0	5
Seville	3	0	1	4
Stockholm	1	0	0	1
Strasbourg	4	0	0	4
Tel-Aviv	4	0	0	4
Toulouse	5	0	0	5
Valencia	1	4	1	6

In summary, 18 cities have routine sources for collecting all the set of core air quality indicators; three cities have 5 indicators out of 6, two have 4 and one has 3 (Table 14).

Table 14: **Cities and number of core air quality indicators**

All the set core of air quality indicators	5 indicators	4 indicators	3 indicators
Barcelona	Bilbao	Le Havre	Bucharest
Bordeaux	Celje	Dublin	
Budapest	Paris		
Cracow			
Ljubljana			
Lille			
London			
Lyon			
Madrid			
Marseille			
Rome			
Rouen			
Seville			
Stockholm			
Strasbourg			
Tel-Aviv			
Toulouse			
Valencia			

Regarding the additional air quality indicators, most cities collect routinely on sulphur dioxide (1 hour average), nitrogen dioxide (maximum 1 hour daily value) and nitrogen monoxide (24 hours average) (Table 15). The rest of indicators are collected with much lower frequency.

Table 15: **Number of cities with routinely collected optional air pollution indicators**

Air quality indicator	Number of cities
1. Black smoke (24 hours average)	14
2. $PM_{2.5}$ (24 hours average)	5
3. Sulphur dioxide: 1 hour average	22
4. Nitrogen dioxide: maximum 1 hour daily value	23
5. Nitrogen monoxide (24 hours average)	21
6. $NO_2 + O_3$ (24 hours average)	9
7. Benzene: daily average	9
8. Benzene: yearly average	10
9. Pollen: daily counts	15

As described for the core set of indicators, there is a high variability in the number and type of monitoring stations in each city (see tables 16-23 below).

Table 16: **Monitoring stations of black smoke, 24 hours average**

	Number of background monitoring stations	Number of traffic monitoring stations	Number of industrial monitoring stations	Total
Barcelona	0	7	1	8
Bilbao	2	3	2	7
Bordeaux	0	0	0	0
Bucharest	0	0	0	0
Budapest	0	0	0	0
Celje	0	0	1	1
Dublin	14	0	0	14
Cracow	12	0	1	13
Le Havre	4	0	3	7
Lille	0	0	0	0
Ljubljana	1	0	1	2
London	12	0	0	12
Lyon	0	2	1	3
Madrid	0	0	0	0
Marseille	2	6	0	8
Paris	11	0	2	13
Rome	0	0	0	0
Rouen	3	1	2	6
Seville	0	0	0	0
Stockholm	0	1	0	1
Strasbourg	0	0	0	0
Tel-Aviv	0	0	0	0
Toulouse	0	0	0	0
Valencia	5	8	1	14

Table 17: **Monitoring stations of $PM_{2.5}$, 24 hours average**

	Number of background monitoring stations	Number of traffic monitoring stations	Number of industrial monitoring stations	Total
Barcelona	0	0	0	0
Bilbao	0	0	0	0
Bordeaux	0	0	0	0
Bucharest	0	0	0	0
Budapest	0	0	0	0
Celje	0	0	0	0
Dublin	0	0	0	0
Cracow	0	0	0	0
Le Havre	0	0	0	0
Lille	0	0	0	0
Ljubljana	0	0	0	0
London	1	1	0	2
Lyon	0	0	0	0
Madrid	0	0	0	0
Marseille	0	0	0	0
Paris	0	0	0	0
Rome	0	0	0	0
Rouen	0	0	0	0
Seville	0	0	0	0
Stockholm	1	1	0	2
Strasbourg	0	0	0	0
Tel-Aviv	2	2	0	4
Toulouse	1	1	0	2
Valencia	0	0	0	0

Table 18: **Monitoring stations of SO_2, 1 hour average**

	Number of background monitoring stations	Number of traffic monitoring stations	Number of industrial monitoring stations	Total
Barcelona	1	3	0	4
Bilbao	2	9	2	13
Bordeaux	4	1	0	5
Bucharest	0	0	0	0
Budapest	2	4	2	8
Celje	1	1	0	2
Dublin	0	0	0	0
Cracow	3	1	0	4
Le Havre	7	0	4	11
Lille	7	1	4	12
Ljubljana	2	0	0	2
London	10	4	0	14
Lyon	16	8	12	36
Madrid	10	24	0	34
Marseille	3	5	0	8
Paris	16	0	3	19
Rome	1	2	0	3
Rouen	7	0	2	9
Seville	0	6	0	6
Stockholm	1	0	0	1
Strasbourg	4	3	2	9
Tel-Aviv	10	0	0	10
Toulouse	1	2	0	3
Valencia	1	4	1	6

Table 19: **Monitoring stations of NO_2, 1 hour daily value**

	Number of background monitoring stations	Number of traffic monitoring stations	Number of industrial monitoring stations	Total
Barcelona	1	4	0	5
Bilbao	4	9	4	17
Bordeaux	4	3	0	7
Bucharest	0	0	0	0
Budapest	2	4	2	8
Celje	1	1	0	2
Dublin	0	1	0	1
Cracow	3	1	0	4
Le Havre	3	1	1	5
Lille	9	5	3	17
Ljubljana	2	0	0	2
London	10	4	0	14
Lyon	4	9	5	18
Madrid	10	24	0	34
Marseille	6	4	0	10
Paris	17	8	0	25
Rome	3	7	0	10
Rouen	3	1	1	5
Seville	1	7	0	8
Stockholm	4	2	0	6
Strasbourg	4	2	0	6
Tel-Aviv	1	5	0	6
Toulouse	5	3	2	10
Valencia	1	4	1	6

Table 20: **Monitoring stations of NO, 24 hours average**

	Number of background monitoring stations	Number of traffic monitoring stations	Number of industrial monitoring stations	Total
Barcelona	1	4	0	5
Bilbao	0	0	0	0
Bordeaux	4	3	0	7
Bucharest	0	0	0	0
Budapest	2	4	2	8
Celje	1	1	0	2
Dublin	0	1	0	1
Cracow	5	1	1	7
Le Havre	3	1	1	5
Lille	9	5	3	17
Ljubljana	1	0	0	1
London	13	10	0	23
Lyon	4	9	5	18
Madrid	10	24	0	34
Marseille	6	4	0	10
Paris	0	0	0	0
Rome	3	7	0	10
Rouen	3	1	1	5
Seville	1	7	0	8
Stockholm	4	2	1	7
Strasbourg	4	2	0	6
Tel-Aviv	1	5	0	6
Toulouse	5	3	2	10
Valencia	1	4	1	6

Table 21: **Monitoring stations of NO_2+O_3, 24 hours average**

	Number of background monitoring stations	Number of traffic monitoring stations	Number of industrial monitoring stations	Total
Barcelona	0	0	0	0
Bilbao	1	0	0	1
Bordeaux	0	0	0	0
Bucharest	0	0	0	0
Budapest	1	1	0	2
Celje	1	0	0	1
Dublin	0	0	0	0
Cracow	0	0	0	0
Le Havre	0	0	0	0
Lille	0	0	0	0
Ljubljana	2	0	0	2
London	0	0	0	0
Lyon	0	0	0	0
Madrid	1	24	0	25
Marseille	0	0	0	0
Paris	0	0	0	0
Rome	2	3	0	5
Rouen	0	0	0	0
Seville	1	2	0	3
Stockholm	1	0	0	1
Strasbourg	0	0	0	0
Tel-Aviv	1	0	0	1
Toulouse	0	0	0	0
Valencia	1	4	1	6

Table 22: **Monitoring stations of benzene, daily average**

	Number of background monitoring stations	Number of traffic monitoring stations	Number of industrial monitoring stations	Total
Barcelona	0	1	0	1
Bilbao	0	0	0	0
Bordeaux	0	0	0	0
Bucharest	0	0	0	0
Budapest	0	0	0	0
Celje	0	0	0	0
Dublin	0	0	0	0
Cracow	0	0	0	0
Le Havre	0	0	0	0
Lille	0	0	0	0
Ljubljana	0	0	0	0
London	1	2	0	3
Lyon	0	1	0	1
Madrid	1	8	0	9
Marseille	0	0	0	0
Paris	2	1	0	3
Rome	1	3	0	4
Rouen	0	0	0	0
Seville	1	0	0	1
Stockholm	1	0	0	1
Strasbourg	1	1	0	2
Tel-Aviv	0	0	0	0
Toulouse	0	0	0	0
Valencia	0	0	0	0

Table 23: **Monitoring stations of benzene, yearly average**

	Number of background monitoring stations	Number of traffic monitoring stations	Number of industrial monitoring stations	Total
Barcelona	0	1	0	1
Bilbao	0	0	0	0
Bordeaux	0	0	0	0
Bucharest	0	0	0	0
Budapest	0	0	0	0
Celje	0	0	0	0
Dublin	0	1	0	1
Cracow	0	0	0	0
Le Havre	0	0	0	0
Lille	0	0	0	0
Ljubljana	0	0	0	0
London	0	0	0	0
Lyon	0	2	0	2
Madrid	1	8	0	9
Marseille	0	0	0	0
Paris	2	1	0	3
Rome	1	3	0	4
Rouen	0	0	0	0
Seville	1	0	0	1
Stockholm	5	2	0	7
Strasbourg	1	1	0	2
Tel-Aviv	0	0	0	0
Toulouse	0	0	0	0
Valencia	1	4	1	6

Overall, 12 centres collect at least 5 optional indicators on AQ, headed by Stockholm, London and Valencia (Table 24).

Table 24: **Cities and number of optional air quality indicators**

City	Number of additional air quality indicators*
Stockholm	8
London	7
Valencia	6 (no data for benzene, nor Pm2.5)
Lyon	6
Madrid	6
Rome	6
Barcelona	6
Celje	5
Ljubljana	5
Paris	5
Seville	5
Tel-Aviv	5
Budapest	4
Cracow	4
Dublin	4
Le Havre	4
Marseille	4
Rouen	4
Strasbourg	4
Toulouse	4
Bilbao	3
Bordeaux	3
Lille	3
Bucharest	0

**Pollen is not included*

All the participants centres have information on the type of method used for measurement; 19 cities have a documented quality assurance/quality control plan and all of them have an estimation on the contribution of the different major emissions sources.

• Health data collection

All centres report having available the daily mortality data on the aggregate level. Nevertheless, the estimated delay in obtaining this kind of data can vary substantially, ranging from 1 month (only in Slovenia) to four years (Tel-Aviv), with a median delay of 18 months (Table 25). A caution needs to be made regarding the availability of individual data, since in most centres substantial restrictions are in place to obtain this information, in most cases as a result of existing national laws on access to personal data.

Table 25: **Estimated delay of mortality data**

City	Months of delay
Ljubljana	1
Celje	1
Seville	6
Valencia	9
Madrid	12
London	12
Budapest	12
Bucharest	12
Barcelona	12
Rome	18
Stockholm (Gotheborg)	18
Bilbao	18
Bordeaux	24
Le Havre	24
Lille	24
Lyon	24
Marseille	24
Paris	24
Toulouse	24
Rouen	24
Strasbourg	24
Dublin	24
Cracow	30
Tel-Aviv	48

All centres except Cracow collect the core set of health indicators (3 centres did not provide this information), with a delay ranging from 1 to 18 months (median delay: 12 months) (Table 26).

Table 26: **Estimated delay of the core set of health indicators**

City	Months of delay
Ljubljana	1
Celje	1
Rome	3
Toulouse	6
Seville	6
Madrid	12
London	12
Budapest	12
Bucharest	12
Bilbao	12
Barcelona	12
Valencia	16
Strasbourg	18
Stockholm (Gotheborg)	18
Rouen	18
Paris	18
Marseille	18
Lille	18
Le Havre	18
Bordeaux	18

(*) Three cities do not provide this information

In most centres data are available on hospital and emergency admissions data, including data grouped by specific causes of admission, generally within one year of delay (Table 27 to Table 30). Information on primary care attendance is seldom available.

Table 27: **Number of cities with hospital admissions data**

	N*	Median Delay (in months)
Set of core health indicators		
1. Respiratory hospital admissions (ICD9 460-519)	23	12
2. Cardiovascular hospital admissions (ICD9 390-459)	23	12
3. Chronic obstructive pulmonary disease (COPD) hospital admissions (ICD9 490-496, excluding 493)	23	12
4. Asthma hospital admissions (ICD9 493)	23	12
5. Ischaemic heart disease (IHD) hospital admissions (ICD9 410-413)	23	12
6. Influenza hospital admissions (ICD9 487)	22	12
Set of additional health indicators		
1. Pneumonia and acute bronchitis hospital admissions (ICD9 466, 480-486)	23	12
2. Cardiac hospital admissions (ICD9 390-459)	23	12
3. Stroke hospital admissions (ICD9 430-438)	23	12
4. Arrhythmia hospital admissions (ICD9 427)	23	12
5. Cardiac failure hospital admissions (ICD9 428)	23	12
6. Total number of emergency admissions	18	12
7. Emergency admissions for respiratory diseases	16	14
8. Emergency admissions for COPD	16	14
9. Emergency admissions for asthma	16	14
10. Emergency admissions for cardiovascular diseases	16	
11. Emergency admissions for ischaemic heart disease	16	
12. Children visits to GPs	2	
13. Emergency prescriptions		
14. Doctors' house calls	2	
15. Medication use	1	
16. Absenteeism	1	
17. Other	2	

**For Crakow all the values of this set are missing.*

Table 28: **Median delay for the additional non-emergency hospital admissions indicators**

	Median Delay (in months)
Celje	1
Ljubljana	1
Rome	3
Seville	6
Toulouse	6
Barcelona	12
Bilbao	12
Bucharest	12
Budapest	12
London	12
Madrid	12
Valencia	16
Bordeaux	18
Le Havre	18
Lille	18
Marseille	18
Paris	18
Rouen	18
Stockholm (Gotheborg)	18
Strasbourg	18
Tel-Aviv	36

Three cities do not provide this information

Table 29: **Median delay for the total number of emergency admissions**

	Median Delay (in months)
Barcelona	1
Celje	1
Ljubljana	1
Seville	6
Toulouse	6
Bilbao	12
Budapest	12
London	12
Valencia	16
Bordeaux	18
Le Havre	18
Lille	18
Marseille	18
Paris	18
Rouen	18
Stockholm (Gotheborg)	18
Tel-Aviv	36
Lyon	?
Bucharest	/
Cracow	/
Madrid	/
Rome	/
Strasbourg	/

Table 30: **Median delay for emergency admissions for respiratory diseases, COPD and asthma**

	Median Delay (in months)
Celje	1
Ljubljana	1
Toulouse	6
Bilbao	12
Budapest	12
London	12
Valencia	16
Bordeaux	18
Le Havre	18
Lille	18
Marseille	18
Paris	18
Rouen	18
Stockholm (Gotheborg)	18
Tel-Aviv	36
Barcelona	/
Bucharest	/
Cracow	/
Lyon	/
Madrid	/
Rome	/
Seville	/
Strasbourg	/

Table 31 summarises the number of optional health indicators in each APHEIS centre. 22 centres collect information on at least 5 optional health indicators, headed by Budapest, with 12 of them.

Table 31: **Number of optional health indicators in each city**

City	Number
Budapest	12
Bilbao	11
Celje	11
London	11
Ljubljana	11
Tel-Aviv	11
Paris	10
Toulouse	10
Barcelona	9
Bordeaux	9
Le Havre	9
Lille	9
Lyon	9
Marseille	9
Rouen	9
Valencia	9
Seville	6
Bucharest	5
Madrid	5
Rome	5
Stockholm	5
Strasbourg	5
Cracow	0

Nineteen cities have changed from ICD9 to ICD10 (London, Ljubljana, Celje, Valencia, Krakow, Paris, Budapest, Madrid, Barcelona, Bilbao, Bucharest, Bordeaux, Le Havre, Lille, Lyon, Marseille, Toulouse, Rouen, and Strasbourg) and in 12 (Stockholm, London, Ljubljana, Celje, Valencia, Cracow, Budapest, Madrid, Bilbao, Dublin, Barcelona and Bucharest) separate data are available for emergency and elective hospital admissions.

• Data collection on confounders

All centres report availability of data on temperature, average humidity, dew point, day of the week and unusual events. Only 7 of them have data on sharp reductions of the population, whereas barometric pressure data are available in 20 centres and wind speed and direction in 19.

Although 20 centres have data on the distribution of the population by sex and age, they rarely are available on an annual basis. 8 centres have data on the prevalence of chronic respiratory disease by sex and age, 9 on smoking prevalence, 9 on the population distribution by occupation and only 3 on the time activity patterns of the population. However, these data are seldom available on an annual basis.

• Data collection on effect modifiers

Most centres collect data on a large number of effect modifiers, especially those regarding climate and health status and socio-demographic information (Table 32).

Table 32: **Number of centres with data on different effect modifiers**

Air pollution mix	
1. Ratio $PM_{2.5}/PM_{10}$	5
2. Ratio NO_2/PM_{10}	17
3. Ratio black smoke/PM_{10}	8
4. Correlation coefficients between different pollutants	18
5. Correlation between different monitoring sites for one pollutant	20
Climate	
6. Annual temperature (°C) (mean, minimum, maximum)	22
7. Seasonal temperature (°C) (mean, minimum, maximum)	22
8. Annual humidity (%) (average)	22
9. Seasonal humidity (%) (average)	22
Health status and socio-demographic data (on an annual basis)	
10. Standardised mortality rate by sex and age in 5 year groups.	21
11. COPD deaths by sex and age in 5 year groups	21
12. Cardiovascular deaths by sex and age in 5 year groups	21
13. Lung cancer incidence rate by sex and age in 5 year groups	9
14. Lung cancer mortality rate by sex and age in 5 year groups	22
15. % of persons over 65 years of age	21
16. Educational level	20
17. Unemployment rates	22
18. Poverty rates	11

• Methodological expertise

Nineteen APHEIS centres report having an experience in air pollution health and 22 have someone in the APHEIS centre with experience in sophisticated statistical methods applied to environmental epidemiology.

6.5. Discussion and conclusions

• Local set-up assessment

Based on the very good response rates from the centres, as well as the overall good informativeness of the responses provided, the following main conclusions can be made:

– There is an overall predominance of an already existing network involvement in the areas of environmental and health monitoring, mostly including public administration agencies, but also research institutions in different instances.

– The initial assessment indicates that for most centres the expected surveillance scenario would be based on daily AQ & HD collection and analysis at local level.

– While air quality data management is mostly undertaken by local level agencies, health and socio-demographic data management tends to involve different levels, local as well as regional and national. Meteorological data tends to be managed by national agencies.

– There is a predominance of an already established framework of collaboration between air quality and health agencies, involving in most cases local and regional agencies.

– There is a varying institutional involvement in data availability, analysis and dissemination, with each agency tending to preserve its role, although in the case of health agencies, the involvement in these different functions tends to be broader.

– Essential human and structural resources needed to support a surveillance system on air pollution and health seem to be generally available at the time of the survey, although prospects for its consolidation need to be further explored.

– There is a predominance of a single agency financing of the centres involved, either from national or local funding.

– The potential users of the surveillance systems identified involved mostly local or local and national level agencies.

– There is a global homogeneity among centres of the proposed profiles for the members to be included in the Institutional and Technical Committee.

– Finally, very few centres expressed the need for pre-launching site visits by the Programme coordinators.

It must be pointed out that the information described refers to the time period at which the information was requested. Since then, some features described in this report may have undergone slight changes, although it is our belief that they would not change the situation described in a substantial manner.

• Compliance with guidelines

– In most cases the APHEIS centres are public health institutions.

– Although most centres do not collect all the data needed by the information system, this information is generally easily accessible to most of them.

– For the case of the APHEIS centres which are academic institutions, the likelihood of a sustained interest on an information system on the effects of air pollution on health connected to the decision-making process needs to be further explored.

– Both the core set of health data and of air quality data are available in most centres. However, the availability of health data is in some cases subject to major delays. This aspect needs to be adequately faced in order to garantee the usefulness of the system.

– Comparability of data quality among APHEIS centres needs to be further explored.

Conclusion and future steps

CONCLUSION AND FUTURE STEPS

Conclusion

APHEIS aims to create an epidemiological surveillance system for health impact assessment (HIA) of air pollution in Europe.

During the first year of the programme, the main objective was to determine and agree on the most appropriate indicators and on the best way to analyse them. To achieve this, experts from five advisory groups, in the fields of public health, air pollution exposure assessment, epidemiology, statistics and health impact assessment, drafted guidelines which defined the environmental and health indicators to be collected, processed and analysed by the APHEIS centres.

The advisory groups also provided general recommendations that stressed the need to keep the epidemiological surveillance system as simple and flexible as possible and the need to adapt the organisational aspects to the particular context of each centre. The advisory groups also stressed that: a) It is essential to ensure the comparability of all measurements made by all APHEIS centres; b) Uncertainties should be discussed thoroughly at each step in the calculations needed for HIA; c) When it is pertinent and available, data provided by European databases, such as AIRBASE, EUROAIRNET, EAN and EUROSTAT should be used.

Finally, the statistics advisory group examined important research questions that have direct implications for epidemiological surveillance and HIA and will require further development.

APHEIS' second objective during its first year was to identify those institutes in the participating centres best able to implement the epidemiological surveillance system. To do so, the programme had to go through two stages. The first stage, the local set-up description, covered aspects relating to local set-up conditions considered important to implement an information system on air pollution and health. The second stage, compliance with guidelines, dealt with measuring each participating centre's compliance with the criteria formulated in each of the five specific areas of the guidelines.

To achieve this aim, two specific questionnaires were sent to each centre to assess its ability to implement the surveillance system. Results showed that: a) Most centres comply with the guidelines, indicating the ability of each local centre to generate basic, standardised reports on a periodic basis; b) Some centres can provide advanced reports on specific issues on a periodic basis.

Future steps

In 2001, during the second year of APHEIS, the programme will test the implementation and functioning of the epidemiological surveillance system in 26 cities in 12 European countries. The work will include:

- Implementing the organisational models proposed (or adapted to each centre's needs) during the first year
- Collecting and processing data on exposure to air pollution; on climate; on health status of the population; and on geographical areas
- Analysing the data using the APHEIS guidelines
- Performing Health Impact Assessment (HIA) in the centres using AirQ
- Preparing a standardised Summary Report including both, a description of the local situation in each centre and the findings of the HIA
- Exploring collaboration with the EUROHEIS programme in the UK (also funded within the programme "Action on pollution related disease") on mapping and HIA.

Meeting its goals

APHEIS aims to provide standardised, periodical reports on the impact of air pollution on health in Europe; and to create an active European public health and environmental information network on air-pollution related diseases. European cities not involved in this feasibility phase of APHEIS have already expressed their willingness to join the programme.

Today, as the next step in fulfilling its mission, APHEIS wishes to make its findings available to different target audiences, and facilitate the comprehension and dissemination of those findings. Decision makers, in particular, need information to guide the management of air quality and of public-health programmes on local, national and European levels.

However, to truly meet the information needs of European decision-makers, environmental health professionals and the general public, APHEIS must function on a continuing, long-term basis. To do so, APHEIS needs the ongoing commitment and financial support of the European Commission and its member states.

Annexes

Annex 1 APHEA2 Methodology

Annex 2 Questionnaires

ANNEX 1 – APHEA2-METHODOLOGY

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ANNEX 1 – APHEA2-METHODOLOGY

DATA

A. Mortality data

Data on mortality will be recorded by age group and by cause of death. Three series of mortality will be analysed: total daily number of deaths (excluding deaths from external causes i.e. excluding those with ICD9≥800), respiratory (ICD9:460-519) and cardiovascular (ICD9:390-459), while 4 age groups will be considered: 15-64 years; 65-74 years; 75+ years and all ages.

Within the APHEA-2 framework, for mortality data, priority will be placed to:

- Total daily number of deaths: all ages and 65+ years
- Respiratory daily number of deaths: all ages
- CVD daily number of deaths: all ages

If information on place of death (i.e. in or out of hospital) is available, even in a few cities, the role of place of death on the estimates of air pollution effects will be investigated.

Mortality data should be available for at least 3 years. If more is possible, the series should start at 1988 and continue until as recently as possible.

B. Hospital admissions

For hospital admissions, data on diagnostic groups described in table 1 should be collected.

TABLE 1: **DIAGNOSTIC GROUPS INCLUDED IN THE APHEA2 ADMISSIONS DATA BASE**

Diagnosis	ICD9
All Respiratory	460-519
Asthma	493
COPD	490-492, 494-496
Pneumonia & acute bronchitis	466, 480-486
Influenza	487
All cardiovascular	390-459
Cardiac	390-429
IHD	410-413
Stroke	430-438
Arrhythmia	427
Cardiac Failure	428

The definition of an “emergency” case should be provided by each group contributing data on hospital admissions. Barcelona will exclude emergency room visits which do not end in admission. In Italy and Paris it is not possible to get emergency admissions and it has been decided not to exclude any diagnostic code.

- The same age groups are reconded for each diagnostic group. The age groups are: 0-14; 15-64; 65-74; 75+ and all ages.

Within the APHEA-2 framework, priority will be given to the following series.

a. Respiratory Admissions

- All Respiratory for ages 65+ years old
- Asthma for 0-14 years and 15-64 years

- Chronic Obstructive Pulmonary Disease (COPD) including asthma admissions for 65+ years. Exploratory analysis using data from London and Barcelona has shown that COPD and asthma admissions series for the elderly, have similar seasonal patterns.

b. Cardiovascular Admissions

- All Cardiac for all ages and for 65+ years
- Ischaemic Heart Disease (IHD) for 0-64 years and for 65+ years
- Stroke for 65+ years

When data are available, transfers from other hospitals and from other areas than the study area will be excluded. Because not every centre has the possibility to look at associated causes, the focus will be only on the main cause of admission. Those centres that cannot distinguish between elective and emergency admissions will focus on the diagnosis reported only for the first service in which the patient is admitted. This should enable us to get as close as possible to the true number of emergency admissions. If this is not possible at a centre(s), it will be clearly stated. Where possible, we have decided to work only with data coded using ICD9.

c. Air pollution data

Daily air pollutants measurements are provided by the monitoring networks established in each town participating in the APHEA-2 project. Measurements done in stations located in limited access highways will be excluded from the analysis. Since only urban air pollution is going to be studied, air pollution monitoring sites situated outside urban areas will not be used, except for O_3 (due to its special pattern of spread).

Completeness criteria

For the calculation of 24 hour NO_2 and SO_2 and maximum one hour NO_2 values, it is required to have at least 75% of the one hour values on that particular day. For the maximum one hour O_3 values, 75% of the hourly values from 6am to 7pm have to be available, since the maximum O_3 levels always occur during day-light. For the eight hour value of O_3, it was decided to take the 9am to 5pm average (since O_3 peaks at or immediately after mid-day and this eight hour average is probably identical or very close to the maximum), and to calculate this, at least six hourly values have to be available. If a station has more than 25% of the values missing for the whole period of analysis it is excluded. In some centres a station may have been closed for a long period. If a nearby station is operating, measurements may be substituted. In this situation, care is taken not to introduce systematic error, because in some cases a nearby (in geographic terms) station, may give systematically different values. In such a case an adjustment may be done (for example if the levels of the substitute station are systematically higher by 25% they are multiplied by 0.8).

Missing data

For each pollutant, a series consisting of the arithmetic mean of daily values of all monitoring stations that fulfill the inclusion criteria, will be constructed. Despite the completeness criteria, there will still be missing values in the air pollutants series for some days (usually for a small proportion of days). Missing air pollution data will be filled in according to the following procedure. The value in a day with missing data in a monitoring station *j* in the year *k* will be replaced by the weighted average of the values of the rest of the monitoring stations, i.e.

$$X_{ijk} = \bar{X}_{i.k} * (\bar{X}_{.jk} / \bar{X}_{..k})$$

For days with missing values in all used monitoring stations, the resulting series will also have a missing value on that date, but this should be a small percentage of the time series. Provided this is less than 5%, the final decision taken during the last Santorini Workshop was to replace these days by using the average of the value of the pollutant of the previous day (to the one with the missing value) and the next day, if these are not missing as well. In case there are consecutive days with missing values they will not be filled in.

d. Data on confounding factors

Time series data on daily temperature (°C, daily mean, min and max) and relative humidity (%) will be used to control for the potential confounding effects of weather. Missing values on the weather series, will be filled in using appropriate regression models. However, in most cities weather series are complete. External information on influenza epidemics or other unusual events (heatwaves, strikes, etc) will be used, if available.

The data on influenza should preferably be daily counts i.e. number of cases. When there are weekly or biweekly data on number of cases, then daily values should be calculated by division. If the only available information is the existence of an epidemic, then a variable taking the value 1 for epidemic days and 0 otherwise should provided. If other unusual events have taken place during the study period (such as: strike in the health services, flood, earthquake, heat or cold wave) a dummy variable with value 1 during the unusual event and 0 otherwise should be included in the file. Furthermore, if in a city, there is a sharp reduction of the population because everyone takes holidays in the same period. This will be indicated.

e. Poisson regression model

Poisson regression will be used to model the health outcome. Generalised Additive Models (GAM) extending Poisson regression will be applied to model the effects of covariates

$$\log(E(Y)) = \sum_{i}^{p} S_i(X_i)$$

where Y is the daily count of the health outcome, X_i the predictor variables, including time, and S_i the smooth functions of those variables. More specifically a loess smoother will be used as, relative to other smoothers, it has a particular local behaviour and will pick up ackward shapes in the data better.

The models will be fitted by maximum likelihood under Poisson model (maximum quasi likelihood) assuming constant over-dispersion over time. The over-dispersion parameter, q, will be estimated by Pearson residual X^2 (McCullagh and Nelder, 1989). For sensitivity analysis, robust Poisson regression will be applied in the final models.

f. Modelling strategy

Serial correlation in the mortality data is only due to some external factors, like season, temperature, or pollutant level. Our objective is to control for those. Reducing the partial autocorrelation function to a white noise after adjustment for all those factors, seems a reasonable objective.

The first step in the analysis will be to control as adequately as possible for seasonal and long-term trends, using a loess smoother. The principle issue in the use of non-parametric smoothers is the choice of the fraction of the data (smoothing parameter) that will be included in the running smooth.

The degree of smoothness can be decided according to “objective” criteria on the basis of goodness of fit (Akaike’s information (AIC) or Schwartz (SC) criteria) or according to a-priori considerations (e.g. set up in advance a limit on how short fluctuations will be controlled for). One needs to remove longer term patterns but leave shorter ones which may reflect causal relationships. Thus, despite its appealing features the decision on the degree of smoothness should not solely depend on “objective” criteria, since this could easily lead in overfiltering, which results in loss of power. In the APHEA-2 project, similarly to the APHEA-1 project, it was decided in advance that the smoothing window should not be reduced below 2 months. So, we start by using a broad smooth, say half a year (i.e. ≈ 183 days) and we adjust (increasing or decreasing the window) it, gradually. To determine the smoothing parameter diagnostic plots will be examined and in particular the graphs of the raw data series, fitted values and the residual plots. Overall, these plots will help to determine how the fit behaves relative to the raw data and how close or how far the residuals are from being “white noise”. Remaining patterns in the data, not picked-up by the model, will be seen in the residuals. Also, one will be able to see if any patterns have been added to the residuals by the choice of the model. Another helpful tool is the PACF (Partial AutoCorrelation Function). The importance of this tool is to

ascertain that data have not been over-fitted or whether substantial serial correlation is present in the residuals. Another important diagnostic plot is the periodogram. AIC can also be used in conjunction with the diagnostic plots.

In some cases loess may not work adequately e.g. for a sharp decrease in summer admissions. In such cases, a dummy variable for summer and an additional smooth or splines may be used.

After seasonal and long-term trends have been controlled for, weather terms will be incorporated into the model. To decide the functional form of temperature and relative humidity as well as the lags of the weather variables that will be used, both AIC and diagnostic plots will be examined. In APHEA-2, same day temperature and a lagged value will be included. The lagged value will be either yesterday's temperature or a few days average. What has been shown from other analyses, is that the same day temperature indicates the heat effect, while the lagged one the cold effect. The need of two smooth functions may vary by cause. Finally, dummy variables for the day of week will be added to the model, while additional dummies for other covariates such as holidays or unusual events will be included if necessary. The necessity of those terms will be judged on the basis of the appropriate F test.

As a control for influenza in the model we have decided to include a dummy variable taking the value 1 for values greater than the 90th percentile of the respiratory mortality. In this way the influenza control will be uniform for all the cities, independently of whether they initially had influenza count data. The correction based on respiratory mortality counts will be applied only in total and a cardiac mortality series. Preliminary sensitivity analysis, comparing this method with the method where inlfuenza cases counts were used, based on data from 3 cities, shown that the use of respiratory mortality counts to control for influenza was adequate. However, the sensitivity analysis will be extended to 8 cities spanning throughout Europe. Another sensitivity analysis for influenza control when respiratory mortality is the outcome will also be carried out. The alternative methods to be evaluated will include: no control; daily counts of influenza cases; and a model based method where a dummy variable (0,1) is defined during influenza epidemics and a smooth term of the interaction of this dummy variable with time is included in the model.

The above procedure is carried out for each health outcome variable in each city separately, so that a "core" model, not necessarily the same for each health outcome, will be constructed for each city.

In the last step, air pollutants will be added to the model. It has been shown that log-transformed air pollutants give the best fit in settings with high levels of air pollution (i.e. higher than 150μg/m^3 for all pollutants except CO). For the sake of meta-analysis, linear terms for all pollutants will be used, restricting the analysis to days with levels of air pollution below 150μg/m^3. However, the choice of the level 150μg/m^3 has been criticised by many participants as being arbitrary. The issue needs further discussion. Dose-response analysis, using GAM models to decide the appropriate functional forms of the air pollutants in the full data sets, will be carried out in specific cities. Multiple pollutant models will be fitted to investigate the independent effects of each pollutant. Interactions with season or age group will also be examined. If there are indications that substantial serial correlation remains in the residuals of the final models (based on diagnostic plots), the final model will be adjusted, as necessary, by changing appropriately the span for season or meteorological variables. If however serial correlation still remains in the residuals, autoregression terms will be added. All analyses will be carried out in S-plus. A special program to fit Autoregressive GAM Poisson models with constant overtime over-dispersion, has been written and is currently being checked.

Methodology used to analyse hospital admissions follows the same strategy as that for mortality. But, if removing serial correlation in mortality appears like a reasonable objective, it can be misleading in hospital admissions. Hospital admissions present a high degree of serial correlation, resulting as for mortality from season, meteorology or pollutant, but also from social factors like day of the week or also some readmissions. Modelling strategy is then slightly modified (compared to mortality) to take into account this dependence. Practically, seasonal control is achieved by looking on PACF after 10 lags. Obtaining a white noise after 10 lags means that we have controlled for long and mid-terms without overfitting. Adjustment on others confounders is similar to that for the mortality series.

In some cases, it may be useful to include dummy variables for school holiday periods or specific holiday periods like Christmas or Easter as well as for the main summer holiday periods. Holidays

such as Christmas, especially if they fall near a weekend, can have quite strong effect on admission numbers.

Additional patterns in the data which occur at specific times in the year, for example, the dip in asthma admissions during the summer holiday period and the subsequent peaks in admissions during the autumn period, can be modelled by using an additional smooth of time specified for these periods only. A single variable is created which is equal to date of study during the periods to be modelled, for all years in the study, and zero at all other dates in the series. A smooth of this new variable is added to the model and the smoothing fraction is determined from the total number of non-zero days in this new variable together with the desired span (a minimum of 60 days has been specified within the APHEA II protocol). If necessary, a local quadratic, rather than linear fit, can be specified in the loess term using the option “degree=2”. This provides a more flexible fit to the data. Indeed, the degree=2 option can be useful for picking up seasonal patterns on the yearly or six monthly time-scale. This method is a crude approximation to a variable span smooth and can remove serial correlation from the short lags without over-fitting the data and inducing patterns in the PACF for longer lags.

If serial correlation still remains in the residuals, autoregression terms will be added.

Lags

Chosing the lag which gives the highest effect estimate was the procedure used in APHEA. This was criticised and we want to address these criticisms in APHEA2. So this time, we are not going to choose the best lag but we will decide a-priori. It was decided to use the average of lags 0 and 1 in all analyses.

Distributed lags will also be investigated on a subset on cities (10-15). The results will be evaluated before further decisions are taken.

Use of robust regression

Robust regression downweighs residuals which are large. So there is less overdispersion and outliers have less influence on the outcome. In S+, in GAM, for robust regression M-estimation is programmed. This reduces the weights (gradually) for residuals outside the $\overline{x} \pm 3s$ range.

It was decided not to use robust regression unless shown to be very necessary. So we will use Poisson GAM (quasi-likelihood) regression and we will get an estimate of overdispersion first.

ANNEX 2 – QUESTIONNAIRES

ANNEX 2 – QUESTIONNAIRES

APHEIS

LOCAL SET UP QUESTIONNAIRE

For modalities of organisation at the local level

Modalities of organisation

From a public health point of view, it is important to optimise the use of information for public health actions. This requires to define the institutional and organisational structure in order to guarantee the availability of data and an effective and efficient dissemination of the results. Some issues which should be defined are the political and institutional support, local/national budget, technical equipment, data availability, and expertise in the relevant fields.

At the local level, if no regulation exists for establishing a surveillance system of the effects of air pollution on health, and if, as it is the case in most cities, the health and environmental data providers and those responsible for the maintenance of the system (integration of data, analysis, and elaboration of reports) are not closely linked, a resistance from health and environmental data providers (in most cases justified by the fear of the use of data) may exist and solutions should be anticipated. An explicit modality of organisation is recommended. It would be based on trust among all the partners, which fully involves data providers in the project, from the provision of data to the interpretation of the analysis and the elaboration of the results to be disseminated.

Resources to maintain the system, analyse and communicate the results in effective ways, taking advantage as much as possible of all the existent data bases, technologies and marketing strategies, should also be planned.

Finally, the organisation model should also guarantee the usefulness of the system, by optimising the dissemination strategies and identifying the potential users of the results (citizens, decision makers, environmental and public health professionals and researchers).

In summary, the true usefulness of a surveillance system depends on how close it remains to public health and environmental decisions.

General objectives

- To guarantee the availability of health and environmental data.
- To guarantee the correct analysis and interpretation of data.
- To guarantee an effective and efficient dissemination of results.

Activities

- To identify the agencies which provide health and environmental data.
- To have an agreement between data providers and those responsible for the maintenance of the surveillance system of the short-term effects of air pollution on health.
- To identify the human resources needed for maintaining the system, analysing data, elaborating the results and disseminating them.
- To identify the structural resources needed for maintaining the system, analysing data, elaborating the results and disseminating them.
- To identify local, regional national potential financing sources
- To identify the potential users of the information.

Basic proposed modality of organisation

At the local level, depending on the city, three different levels should be considered. A strong political commitment is desirable, although sometimes it is difficult to get at the beginning. A steering committee is strongly recommended in order to guarantee the survival of the system in the long-term. It includes the Directors of the agencies who provide the data and the person responsible of the maintenance of the system.

A technical committee should also be made explicit, with the resources for the maintenance of the system and the dissemination of results with timeliness. Moreover, depending on the internal resources, an external advisory committee can also be necessary.

Finally, in order to optimise the use of the results, different users and ways of dissemination should be identified.

The table below illustrates one possible model of organisation. Modifications should be necessary depending on the specific characteristics of the city.

Local steering committee

	Institutional representation	Functions
Chairman	Agency responsible for maintaining the surveillance system (public health agency?)	1. The steering committee is formed by the Directors of the agency responsible for maintaining the surveillance system and those of the agencies providing the data.
Vice-Chairman	Data provider (environmental agency?)	
Committee member	Data provider (Health statistics agencies?)	
Committee member	Data provider (other relevant agencies, e.g. meteorology agency)	2. This steering committee is responsible for the decisions on the activities and the dissemination of information on APHEIS.

Local technical committee

Core group		Functions
Technical director	Technical responsible for maintaining the surveillance system	This group is responsible for the maintenance of the surveillance system, the analysis of data, the regular feed-back to the steering committee and the elaboration of the different dissemination reports.
Technical co-directors (to be considered)	A technical co-direction from data providers agencies (environmental and health data)	
Technical assistant	Statistician or environmental epidemiologist Data manager	
Advisory group		
	Exposure assessment Environmental epidemiology Statistics Communication strategies	The members of the advisory groups should provide advice on the issues in which they are specialised.

Other possible groups: Grass-roots organisations, NGOs, etc.

The following questionnaire will enable us to prepare the feasibility test on the implementation of the programme.

It should be completed and sent back within four weeks

And, in any case, not later than May 5

Thank you

APHEIS

LOCAL SET UP QUESTIONNAIRE

Check-list of feasibility

1. Local co-ordinator:

First name: .....

Last name: .....

Title: .....

Position: .....

Institution:

Public Health Administration

- ☐ Local level
- ☐ Regional level
- ☐ National level
- ☐ Other

University/Research ☐

Environmental Administration

- ☐ Local level
- ☐ Regional level
- ☐ National level
- ☐ Other

Private ☐

Other: .....

.....

.....

Address (number, street, city, postcode, and country)

.....

.....

.....

Telephone numbers (mobile included):

Fax number: .....

Email address: .....

2. Participating country: .....

3. Is your city/setting linked to a national/regional network of cities/settings?:

Yes ☐ No ☐

• If yes, please specify:

.....

.....

ANNEX 2

• Number of cities participating in the program and their name:

4. Scenario of collaboration

There are three basic levels of collaboration at the centre level:

Please tick the right answer

Choose the scenario which you think would better fit in with your local situation:

1. Centre with daily AP and health data collection and analysis at a local level ☐

2. Centre with daily AP and health data collection and analysis at the European co-ordinating centre ☐

3. Centre with local annual AP data for HIA using Exposure- Response functions, produced in the "more intensive" participating centres, and analysis at the European co-ordinating centre ☐

Other:

Role	Organisation
Air Quality data collection:	
Air Quality analysis:	
Air Quality data dissemination:	
Compliance with regulations:	
Other:	

6. Which organisation(s) is (are) in charge of health–related issues in your city (cities)?

Who is in charge of the following: data collection, analysis, surveillance, dissemination, other?

Role	Organisation
Health data collection:	
Health data analysis:	
Health surveillance:	
Health data dissemination:	
Other:	

7. Which organisation(s) is (are) in charge of sociodemographic data in your city (cities)?

Who is in charge of the following: data collection, analysis, dissemination, other?

Role	Organisation
Sociodemographic data collection:	
Sociodemographic data analysis:	
Sociodemographic data dissemination:	
Other:	

8. Which organisation is in charge of meteorological data in your city (cities)?

Who is in charge of the following: data collection, analysis, dissemination, other?

Role	Organisation
Meteorological data collection:	
Meteorological data analysis:	
Meteorological data dissemination:	
Other:	

9. Is there an established framework of collaboration between Environmental and Health organisations for shared relevant programs?

Yes ☐ No ☐

If yes,

Choose all applicable answers:

Type of collaboration	Technical	Institutional
At a city level?	☐	☐
At a regional level?	☐	☐
At a national level?	☐	☐

10. Is there any social or grass-roots framework for environmental health issues that is external (or partially related) to public administrations?

If yes, please specify:

.....

.....

.....

.....

In the case of a development of a routine information system to monitor the health effects of air pollution in your city, the extent to which the data providers agencies and the centre co-ordinator want to collaborate, should be made explicit (just making data available or also collaborating in the analysis and the dissemination of results?)

11. Agreement of collaboration

Choose all applicable answers:

Level of involvement	Air pollution data agency	Health data agency (or agencies)	Sociodemographic agency (or agencies)	Meteorological agency	Co-ordinating Centre
Data availablity:					
– air pollution data	☐	☐	☐	☐	☐
– health data	☐	☐	☐	☐	☐
– sociodemographic data	☐	☐	☐	☐	☐
– meteorological data	☐	☐	☐	☐	☐
Analysis					
Building daily indicators on:					
– air pollution data	☐	☐	☐	☐	☐
– health data	☐	☐	☐	☐	☐
– sociodemographic data	☐	☐	☐	☐	☐
– meteorological data	☐	☐	☐	☐	☐
Doing local statistical analysis	☐	☐	☐	☐	☐
Participating in the meta–analysis	☐	☐	☐	☐	☐
Dissemination	☐	☐	☐	☐	☐

12. Human resources available for the maintenance of the surveillance system

Choose all applicable answers:

	Availability	
	Internal	**Advisor**
Co-ordinator of the system	☐	☐
Data manager	☐	☐
Environmental epidemiologist	☐	☐
Environmental statistician	☐	☐
Exposure assessment expert	☐	☐
Communication strategies expert	☐	☐

13. Structural resources (minimum list of requirements)

Choose all applicable answers:

	Availability
Number of computers	☐
Photocopier	☐
Access to internet	☐
Personnel:	
Secretary	☐
Web page designer	☐
Does the agency have its own Web site?	☐
Statistic package (which)	☐
Other resources (specify)	
.....	
.....	
.....	

In the case of a development of a routine information system to monitor the health effects of air pollution in your city, who do you think would be:

14. The potential financing sources of the information program:

Choose all applicable answers:

1. Local authorities ☐

2. Regional authorities ☐

3. National authorities ☐

4. Public health agencies ☐

5. Air pollution networks ☐

6. Environmental agencies ☐

7. ☐

8. Others.....

.....

.....

.....

15. The potential users of the information program

Choose all applicable answers

	Local	Regional	National
Decision markers			
Authorities involved in air quality management	☐	☐	☐
Authorities involved in public health management	☐	☐	☐
Authorities involved in health services management	☐	☐	☐
Authorities involved in urban planning management	☐	☐	☐
NEHAPS	☐	☐	☐
Others (to be identified)	☐	☐	☐
Professionals (researchers)			
Universities	☐	☐	☐
Public health researchers	☐	☐	☐
Health services researchers	☐	☐	☐
Clinical researchers	☐	☐	☐
Environmental researchers	☐	☐	☐
Air pollution networks	☐	☐	☐
Economists	☐	☐	☐
Others (to be identified)	☐	☐	☐
Citizen associations*:			
Political parties	☐	☐	☐
Ecologists	☐	☐	☐
Neighbour associations	☐	☐	☐
Unions	☐	☐	☐
Schools	☐	☐	☐
Others (to be identified)	☐	☐	☐

* Citizens, in general, are also potential users of the information

16. The potential partners of the information program for the "technical" committee:

Choose all applicable answers:

1. Exposure assessment experts/air pollution networks ☐

2. Epidemiologists ☐

3. Statisticians ☐

4. Public health professionals ☐

5. Health impact assessment experts ☐

6. Others.....

.....

.....

17. The potential partners of the information program for the "institutional" committee:

Choose all applicable answers:

Local authorities ☐
Regional authorities ☐
National authorities ☐
Public health agencies ☐
Air pollution networks ☐
Environmental agencies ☐
Researchers in medical sciences ☐
Researchers in environmental sciences ☐
NEHAPS ☐
Others .....

.....

.....

18. Do you think it is really necessary, before launching the project, that one program co-ordinator comes to your centre to present APHEIS?

Yes ☐ No ☐

19. If yes,

Which partners would you invite to the meeting?

.....

.....

.....

.....

.....

.....

.....

When would you plan the visit?

May **first** half ☐
May **second** half ☐

20. Date of response to the questionnaire:

APHEIS

FEASIBILITY QUESTIONNAIRE

Please, excuse possible redundancies with previous questionnaires

The health surveillance system proposed by APHEIS implies the integration of health, environmental and sociodemographic data, and an experience in health impact assessment and/or a rather sophisticated statistical analysis. Therefore, the feasibility of the system depends on the data available at the local level, on the difficulties in receiving them at the APHEIS centre, and on the potential need of external technical support for statistical analysis.

This questionnaire aims at getting information on indicators of feasibility. Please, be as precise as possible. When an APHEIS centre co-ordinates more than one city with different characteristics for some of the questions, please complete separate questionnaire for each city (or group of cities with the same characteristics). Thank you.

First part: Identification

A. APHEIS participant: Local coordinator

Name ..... First name .....

Title .....

B. APHEIS centre:

City .....

Name of the institution .....

Second part: Indicators of feasibility

C. Data sources

C.1. Air quality data

➤ C.1.1. Are they routinely collected at the APHEIS centre?

☐ Yes *(skip to C.2)*
☐ No

➤ C.1.2. Is the agency …?

☐ Local
☐ Regional
☐ National

➤ C.1.3. What is the name of the agency that provides environmental data?

.....

➤ C.1.4. Is there a framework of collaboration between the APHEIS centre and the agency?

☐ Yes
☐ No, but it is easy to get
☐ No, and it is difficult to get

C.2. Meteorological data source

➤ C.2.1. Are they routinely collected at the APHEIS centre?

☐ Yes *(skip to C.3)*
☐ No

➤ C.2.2. Is the meteorological agency …?

☐ Local
☐ Regional
☐ National

➤ C.2.3. What is the name of the agency that provides meteorological data?

.....

➤ C.2.4. Is there a framework of collaboration between the APHEIS centre and the meteorological agency?

☐ Yes
☐ No, but it is easy to get
☐ No, and it is difficult to get

C.3. Sociodemographic data

➤ C.3.1. Are they routinely collected at the APHEIS centre?

☐ Yes *(skip to C.4.)*
☐ No

➤ C.3.2. Is the agency responsible for the sociodemographic data …?

☐ Local
☐ Regional
☐ National

➤ C.3.3. What is the name of the agency that provides sociodemographic data?

.....

➤ C.3.4. Is there a framework of collaboration between the APHEIS centre and the sociodemographic agency?

☐ Yes

☐ No, but it is easy to get

☐ No, and it is difficult to get

C.4. Mortality data

➤ C.4.1. Are they routinely collected at the APHEIS centre?

☐ Yes *(skip to C.5.)*

☐ No

➤ C.4.2. Is the agency responsible for mortality data …?

☐ Local

☐ Regional

☐ National

➤ C.4.3. What is the name of the agency that provides mortality data?

.....

➤ C.4.4. Is there a framework of collaboration between the APHEIS centre and the agency responsible for mortality data?

☐ Yes

☐ No, but it is easy to get

☐ No, and it is difficult to get

C.5. Hospital admissions data

➤ C.5.1. Are hospital admissions data routinely collected at the APHEIS centre?

☐ Yes *(skip to D.)*

☐ No

➤ C.5.2. Is the health agency…?

☐ Local

☐ Regional

☐ National

➤ C.5.3. What is the name of the agency that provides hospital admission data?

.....

➤ C.5.4. Is there a framework of collaboration between the APHEIS centre and the health agency?

☐ Yes

☐ No, but it is easy to get

☐ No, and it is difficult to get

D. Exposure data

	Routine source[1]	Number of background[2] monitoring stations	Number of traffic[3] monitoring stations	Number of industrial[4] monitoring stations	Seasonal level available[5]	Minimum delay for transmission of data[6]	Approximate delay for updating[7]
Core set of air pollution indicators							
1. PM_{10} (24 hours average)	☐	☐☐	☐☐	☐☐	☐	☐☐	☐☐
2. Sulphur dioxide (24 hours average)	☐	☐☐	☐☐	☐☐	☐	☐☐	☐☐
3. Nitrogen dioxide (24 hours average)	☐	☐☐	☐☐	☐☐	☐	☐☐	☐☐
4. Carbon monoxide: maximum 8-hour average	☐	☐☐	☐☐	☐☐	☐	☐☐	☐☐
5. Ozone: maximum 8 hours	☐	☐☐	☐☐	☐☐	☐	☐☐	☐☐
6. Ozone: maximum 1 hour daily value	☐	☐☐	☐☐	☐☐	☐	☐☐	☐☐

[1] Routine source = the data is collected permanently, in a routine manner, in the data source
[2] Background = population related (i.e., uninfluenced by traffic or other sources in the direct vicinity of the measurement site)
[3] Traffic stations used for monitoring traffic induced air pollution
[4] Industrial stations used for monitoring industrial air pollution
[5] Seasonal levels as an effect modifier
[6] The minimum delay for transmission of data refers to the minimum time needed for transmission of data from the source to the APHEIS centre.
[7] Delay for updating refers to the time between the date of reception of data at the APHEIS centre and the time to which the data refers.

	Routine source[8]	Number of background[9] monitoring stations	Number of traffic[10] monitoring stations	Number of industrial[11] monitoring stations	Seasonal level available[12]	Minimum delay for transmission of data[13]	Approximate delay for updating[14]
Optional air pollution indicators							
7. Black smoke (24 hours average)	☐	☐☐	☐☐	☐☐	☐	☐☐	☐☐
8. $PM_{2.5}$ (24 hours average)	☐	☐☐	☐☐	☐☐	☐	☐☐	☐☐
9. Sulphur dioxide: 1 hour average	☐	☐☐	☐☐	☐☐	☐	☐☐	☐☐
10. Nitrogen dioxide: maximum 1 hour daily value	☐	☐☐	☐☐	☐☐	☐	☐☐	☐☐
11. Nitrogen monoxide (24 hours average)	☐	☐☐	☐☐	☐☐	☐	☐☐	☐☐
12. $NO_2 + O_3$ (24 hours average)	☐	☐☐	☐☐	☐☐	☐	☐☐	☐☐
13. Benzene: daily average	☐	☐☐	☐☐	☐☐	☐	☐☐	☐☐
14. Benzene: yearly average	☐	☐☐	☐☐	☐☐	☐	☐☐	☐☐
15. Pollen: daily counts[15]	☐	☐☐	☐☐	☐☐	☐	☐☐	☐☐

[8] Routine source = the data is collected permanently, in a routine manner, in the data source
[9] background = population related (i.e., uninfluenced by traffic or other sources in the direct vicinity of the measurement site)
[10] traffic stations used for monitoring traffic induced air pollution
[11] industrial stations used for monitoring industrial air pollution
[12] Seasonal levels as an effect modifier
[13] The minimum delay for transmission of data refers to the minimum time needed for transmission of data from the source to the APHEIS centre.
[14] Delay for updating refers to the time between the date of reception of data at the APHEIS centre and the time to which the data refers.
[15] Pollen counts as a confounder

16. Do you have information on the type of method/principle used for measurement (i.e. UV Fluorescence, Chemiluminescence, UV Absorption, Beta absorption, TEOM, Gravimetric, Reflectometry, for Black smoke the type of reflectometer and the filter type).

☐ Yes, for all measured pollutants

☐ Yes, but for the following pollutants only: .....

☐ No

17. Do stations have a documented quality assurance/quality control plan?

☐ Yes
☐ No

18. Do you have information on the contribution of different major emissions sources to the pollution of the city (traffic, industries, etc.)?

☐ Yes
☐ No

E. Health data

E.1. Daily mortality data

	Routine source[16]	Minimum delay for transmission of data[17]	Approximate delay for updating[18]
1. Total number of deaths (ICD9<800)	☐	⌊__⌋	⌊__⌋
2. Total number of deaths (ICD9<800), 15-64 years	☐	⌊__⌋	⌊__⌋
3. Total number of deaths (ICD9<800), 65-74 years	☐	⌊__⌋	⌊__⌋
4. Total number of deaths (ICD9<800), 75+ years	☐	⌊__⌋	⌊__⌋
5. Number of respiratory deaths (ICD9 460-519)	☐	⌊__⌋	⌊__⌋
6. Number of respiratory deaths (ICD9 460-519), 15-64 years	☐	⌊__⌋	⌊__⌋
7. Number of respiratory deaths (ICD9 460-519), 65-74 years	☐	⌊__⌋	⌊__⌋
8. Number of respiratory deaths (ICD9 460-519), 75+years	☐	⌊__⌋	⌊__⌋
9. Number of cardiovascular deaths (ICD9 390-459)	☐	⌊__⌋	⌊__⌋
10. Number of cardiovascular deaths (ICD9 390-459), 15-64 years	☐	⌊__⌋	⌊__⌋
11. Number of cardiovascular deaths (ICD9 390-459), 65-74 years	☐	⌊__⌋	⌊__⌋
12. Number of cardiovascular deaths (ICD9 390-459), 75+ years	☐	⌊__⌋	⌊__⌋

[16] Routine source = the data is collected permanently, in a routine manner, in the data source
[17] The minimum delay for transmission of data refers to the minimum time needed for transmission of data from the source to the APHEIS centre.
[18] Delay for updating refers to the time between the date of reception of data at the APHEIS centre and the time to which the data refers.

E.2. Daily hospital admissions data

	Routine source	Minimum delay for transmission of data[19]	Approximate delay for updating[20]
Set of core health indicators			
1. Respiratory hospital admissions (ICD9 460-519)	☐	⌊__⌋	⌊__⌋
2. Respiratory hospital admissions (ICD9 460-519), <15 years	☐	⌊__⌋	⌊__⌋
3. Respiratory hospital admissions (ICD9 460-519), 15-64 years	☐	⌊__⌋	⌊__⌋
4. Respiratory hospital admissions (ICD9 460-519), 65+ years	☐	⌊__⌋	⌊__⌋
5. Cardiovascular hospital admissions (ICD9 390-459)	☐	⌊__⌋	⌊__⌋
6 Cardiovascular hospital admissions (ICD9 390-459), <15 years	☐	⌊__⌋	⌊__⌋
7. Cardiovascular hospital admissions (ICD9 390-459), 15-64 years	☐	⌊__⌋	⌊__⌋
8. Cardiovascular hospital admissions (ICD9 390-459), 65+ years	☐	⌊__⌋	⌊__⌋
9. Chronic obstructive pulmonary disease (COPD) hospital admissions (ICD9 490-496, excluding 493)	☐	⌊__⌋	⌊__⌋
10. Chronic obstructive pulmonary disease (COPD) hospital admissions (ICD9 490-496, excluding 493), < 15 years	☐	⌊__⌋	⌊__⌋
11. Chronic obstructive pulmonary disease (COPD) hospital admissions (ICD9 490-496, excluding 493), 15-64 years	☐	⌊__⌋	⌊__⌋
12. Chronic obstructive pulmonary disease (COPD) hospital admissions (ICD9 490-496, excluding 493), 65+ years	☐	⌊__⌋	⌊__⌋
13. Asthma hospital admissions (ICD9 493)	☐	⌊__⌋	⌊__⌋
14. Asthma hospital admissions (ICD9 493), <15 years	☐	⌊__⌋	⌊__⌋
15. Asthma hospital admissions (ICD9 493), 15-64 years	☐	⌊__⌋	⌊__⌋
16. Asthma hospital admissions (ICD9 493), 65+ years	☐	⌊__⌋	⌊__⌋
17. Ischaemic heart disease (IHD) hospital admissions (ICD9 410-413)	☐	⌊__⌋	⌊__⌋
18. Ischaemic heart disease (IHD) hospital admissions (ICD9 410-413), <15 years	☐	⌊__⌋	⌊__⌋
19. Ischaemic heart disease (IHD) hospital admissions (ICD9 410-413), 15-64 years	☐	⌊__⌋	⌊__⌋
20. Ischaemic heart disease (IHD) hospital admissions (ICD9 410-413), 65+years	☐	⌊__⌋	⌊__⌋
21. Influenza hospital admissions (ICD9 487)[21]	☐	⌊__⌋	⌊__⌋

[19] The minimum delay for transmission of data refers to the minimum time needed for transmission of data from the source to the APHEIS centre.
[20] Delay for updating refers to the time between the date of reception of data at the APHEIS centre and the time to which the data refers.
[21] Influenza hospital admissions as a confounder

	Routine source	Minimum delay for transmission of data[22]	Approximate delay for updating[23]
Set of additional health indicators			
22. Pneumonia and acute bronchitis hospital admissions (ICD9 466, 480-486)	☐	__| __	__| __
23. Cardiac hospital admissions (ICD9 390-459)	☐	__| __	__| __
24. Stroke hospital admissions (ICD9 430-438)	☐	__| __	__| __
25. Arrhythmia hospital admissions (ICD9 427)	☐	__| __	__| __
26. Cardiac failure hospital admissions (ICD9 428)	☐	__| __	__| __
27. Total number of emergency admissions	☐	__| __	__| __
28. Emergency admissions for respiratory diseases	☐	__| __	__| __
29. Emergency admissions for COPD	☐	__| __	__| __
30. Emergency admissions for asthma	☐	__| __	__| __
31. Emergency admissions for cardiovascular diseases	☐	__| __	__| __
32. Emergency admissions for ischaemic heart disease	☐	__| __	__| __
33. Children visits to GPs	☐	__| __	__| __
34. Emergency prescriptions	☐	__| __	__| __
35. Doctors' house calls	☐	__| __	__| __
36. Medication use	☐	__| __	__| __
37. Absenteeism	☐	__| __	__| __
38. Other health outcomes routinely collected. Please, specify			
.....			

[22] The minimum delay for transmission of data refers to the minimum time needed for transmission of data from the source to the APHEIS centre.
[23] Delay for updating refers to the time between the date of reception of data at the APHEIS centre and the time to which the data refers.

E.3. Has the coding system changed from ICD9 to ICD10?

☐ Yes. Year of change .....

☐ No

E.4. Are separate data available for emergency and elective hospital admissions?

☐ Yes

☐ No

F. Confounders

F.1. Confounders on short-term relationships (on a daily basis)

	Routine source	Minimum delay for transmission of data[24]	Approximate delay for updating[25]
Meteorological data			
1. Temperature (°C) (average, minimum and maximum)	☐	__|	__|
2. Average humidity(%)	☐	__|	__|
3. Dew point (ºC)	☐	__|	__|
For each day, concurrent information on			
4. Day of the week	☐	__|	__|
5. Holiday (bank, school)	☐	__|	__|
6. Unusual event	☐	__|	__|
7. Sharp reduction of the population	☐	__|	__|
8. Influenza epidemics	☐	__|	__|
Set of optional indicators			
9. Barometric pressure	☐	__|	__|
10. Wind speed and direction	☐	__|	__|

[24] The minimum delay for transmission of data refers to the minimum time needed for transmission of data from the source to the APHEIS centre.
[25] Delay for updating refers to the time between the date of reception of data at the APHEIS centre and the time to which the data refers.

F.2. Confounders on long-term relationships (on an annual basis)

	Routine source	Minimum delay for transmission of data[24]	Approximate delay for updating[25]
Core set of indicators			
11. Population of the study area by sex and age in 5 year groups	☐	__|	__|
12. Prevalence of chronic respiratory disease by sex and age in 5 years groups	☐	__|	__|
13. Smoking prevalence by sex and age in 5 year groups	☐	__|	__|
Set of optional indicators			
14. Population distribution by occupation	☐	__|	__|
15. Time activity patterns of the population in the study area (% spent outdoors and in transports)	☐	__|	__|

[24] The minimum delay for transmission of data refers to the minimum time needed for transmission of data from the source to the APHEIS centre.
[25] Delay for updating refers to the time between the date of reception of data at the APHEIS centre and the time to which the data refers.

G. Effect modifiers

G.1. Air pollution mix

	Routine source	Minimum delay for transmission of data[26]	Approximate delay for updating[27]	Seasonal level available
19. Ratio $PM_{2.5}/PM_{10}$	☐	☐☐	☐☐	☐
20. Ratio NO_2/PM_{10}	☐	☐☐	☐☐	☐
21. Ratio black smoke/PM_{10}	☐	☐☐	☐☐	☐
22. Correlation coefficients between different pollutants	☐	☐☐	☐☐	☐
23. Correlation between different monitoring sites for one pollutant	☐	☐☐	☐☐	☐

[26] The minimum delay for transmission of data refers to the minimum time needed for transmission of data from the source to the APHEIS centre.
[27] Delay for updating refers to the time between the date of reception of data at the APHEIS centre and the time to which the data refers.

G.2. Climate

	Routine source	Minimum delay for transmission of data	Approximate delay for updating
24. Annual temperature (°C) (mean, minimum, maximum)	☐	☐☐	☐☐
25. Seasonal temperature (°C) (mean, minimum, maximum)	☐	☐☐	☐☐
26. Annual humidity (%) (average)	☐	☐☐	☐☐
27. Seasonal humidity (%) (average)	☐	☐☐	☐☐

G.3. Health status and sociodemographic data (on an annual basis)

	Routine source	Minimum delay for transmission of data	Approximate delay for updating
28. Standardized mortality rate by sex and age in 5 year groups	☐	☐☐	☐☐
29. COPD deaths by sex and age in 5 year groups	☐	☐☐	☐☐
30. Cardiovascular deaths by sex and age in 5 year groups	☐	☐☐	☐☐
31. Lung cancer incidence rate by sex and age in 5 year groups	☐	☐☐	☐☐
32. Lung cancer mortality rate by sex and age in 5 year groups	☐	☐☐	☐☐
33. % of persons over 65 years of age	☐	☐☐	☐☐
34. Educational level	☐	☐☐	☐☐
35. Unemployment rates	☐	☐☐	☐☐
36. Poverty rates	☐	☐☐	☐☐

G.4. Geographical data

Is information available on:

• area size?

☐ Yes

☐ No

• longitude/latitude?

☐ Yes

☐ No

H. Data analysis

H.1. Does anyone in the local APHEIS centre have an experience in air pollution health impact assessment?

☐ Yes (please, give a reference to the completed / conducted analysis) .....

.....

☐ No

H.2. Does anyone in the local APHEIS centre have an experience in sophisticated statistical methods applied to environmental epidemiology (GAM, time series studies, etc.?)

☐ Yes (please, give a reference to the completed / conducted analysis) .....

.....

☐ No