AirMonTech

Adjusting supply and demand:
What Epidemiology needs from AQ monitoring

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Outline

- How do policy makers and health researchers interact?
- What do epidemiological studies produce?
  - Short-term effect studies (time resolution)
  - Long-term effect studies (spatial resolution)
- Regulated monitoring (top-down)
- Monitoring within projects (bottom up)
- What type of monitoring for health effects research?
- What type of data for health effects research?
- Open questions in health effects research
- Proposals for monitoring strategies from a health research point of view

Why is air quality monitored?

Most would answer: to monitor compliance with the legislation

But why is there legislation to keep the concentrations of some air pollutants low?

Because there is scientific evidence that there are adverse health effects when the concentrations are "high".

Which level is "high" is again determined by toxicological or epidemiological studies.

And why do we have studies on the health effects of air pollution?

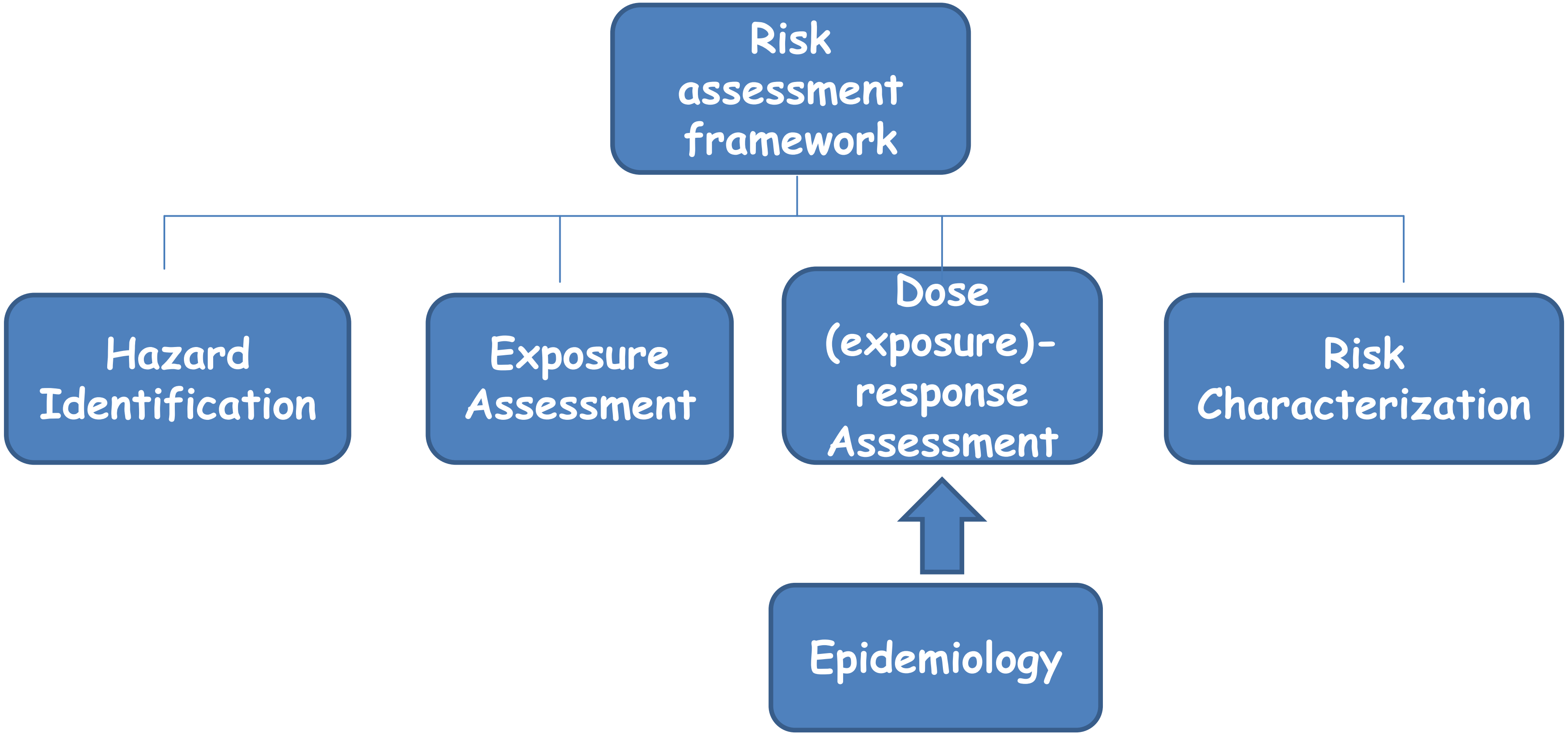
The ultimate goal is to inform policy decisions and air quality management so that decisions and policies actually protect public health in the best possible way

Therefore those who implement health studies will have to talk to policy makers and vice versa

What type of evidence is useful to support the public health decision making process?

- For a specific public health problem the decision-maker needs to know
  - How important is the problem for his/her area
  - A quantified estimate of the health burden it causes
  - A quantified illustration of the uncertainty around the estimated burden

What is needed is a risk -or, better, a health impact- assessment



How are these exposure-response associations usually expressed in epidemiological study results?

- In terms of odds ratios (OR), rate or risk ratios (RR), hazard ratios
- These talk about the increase in the probability of having an effect when the exposure increases by a certain amount or category

An operational classification of the adverse effects of air pollution on health is in short-term effects (same day, or up to a few days) and long-term effects (years or life-long).

Their study requires different designs which have different needs for exposure measurements:

For the study of short-term effects a fine time resolution is needed (typically daily measurements, e.g. 24h PM_{10} concentrations; max 1-hour ozone concentration for every day)

For the study of long-term effects a fine spatial resolution is needed (e.g. measurements in various areas within a city, complemented by appropriate models to downscale to every point within an area)

Short-term effect studies need time series of exposure

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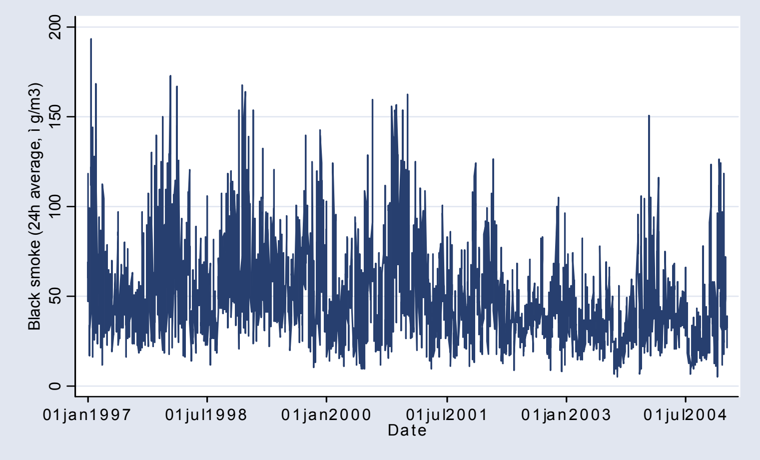
Mostly, exposure data used in these come form routinely operated monitoring sites.

Older studies used measurements available from the monitoring networks, at that time mainly measuring Black Smoke (BS) in Europe; TSP and later PM_{10} in the US.



After the PM_{10} standards were introduced in the U.S. (1987) and Europe (1999) and the $PM_{2.5}$ standard in the US (1997) and Europe (2008), short-term studies accumulated on the effects of these two metrics.

The exposure-response given for short-term effects

Often assumes a linear underlying association,
as there is no evidence to support a deviation from linearity,
and quantifies for example (if we take a specific exposure-outcome pair)

the % increase in the daily number
of emergency respiratory hospital admissions
associated with a specific increase
in the concentration of the pollutant of interest
by, say, 10μg/m^3

Short-term effects of PM_{10} on health. Results from the multi-city U.S. (H.E.I funded) project “National Mortality, Morbidity and Air Pollution Study” (NMMAPS) Samet et al 2000; NEJM 343: 1742-9

Mortality	% (95% CI) increase in outcome per 10μg/m³ increase in PM_{10}
All natural causes	0.5 (0.1-0.9)
Cardio-respiratory causes	0.7 (0.2, 1.2)

Short-term effects of PM on health. Results from the multi-centre European project "Air Pollution and Health: a European Approach" (APHEA2)

	% (95% CI) increase in outcome per $10 \mu g/m^3$ increase in pollutant	
Mortality	PM_{10} or TSP*	Black smoke
All natural causes (APHEA2, 21 cities, lags 0 and 1; Epidemiology 2001; 12: 521-31)	0.6 (0.4-0.8)	0.6 (0.3-0.8)
Cardiovascular causes (APHEA2 , 21 cities, lags 0 and 1; Epidemiology 2006;17:230-3)	0.8 (0.5, 1.1)	0.6 (0.4, 0.9)
Respiratory causes (APHEA2 , 21 cities, lags 0 and 1; Epidemiology 2006;17:230-3)	0.6 (0.2, 1.0)	0.8 (0.1, 1.6)
* PM_{10} was mostly calculated from fragmented measurements and modeled estimations, to produce comparable data		

Long-term studies need a good spatial resolution of exposure

The most influential study of long-term effects of pollutants until today has been the American Cancer Society (ACS) study.

This investigated the effects of air pollution exposure on mortality in 500,000 US inhabitants living in 151 cities and used the EPA monitoring system

U.S. ACS study: Adjusted mortality relative risks (RR) associated with 10μg/m³ change in $PM_{2.5}$* (Pope et al, 2002)

Cause of mortality	RR* (95% CI)
All cause	1.06 (1.02 - 1.11)
Lung cancer	1.14 (1.04 - 1.23)
Cardiopulmonary	1.09 (1.03 - 1.16)
All other cause	1.01 (0.95 - 1.06)

*Adjusted for age, sex, race, smoking, education, marital status, body mass, alcohol consumption, occupational exposure, diet.

Clearly the number & the quality of studies, as well as the kind of the results provided (i.e. which PM index is studied) depend on the measurements made available to the researchers by the established routine monitoring networks.

So far the decision makers regulating the routine air pollution monitoring in Europe have not been responsive to the needs of research.

They request adequate evidence on health effects before a regulation is introduced.

However, adequate evidence can only be produced when adequate measurements become available.

The scientific community responded

The scientific community responded by doing ad hoc measurement campaigns for the needs of specific studies (e.g. the ESCAPE project)

This is more easily done for the requirements of long-term effect studies, where the need focuses on the long-term estimation of personal exposure. However, the production of relevant health data is more difficult and expensive for these studies.

It is more expensive to produce daily time-series for the needs of assessing short-term effects. However, here the production of relevant health data is much easier and cheaper.

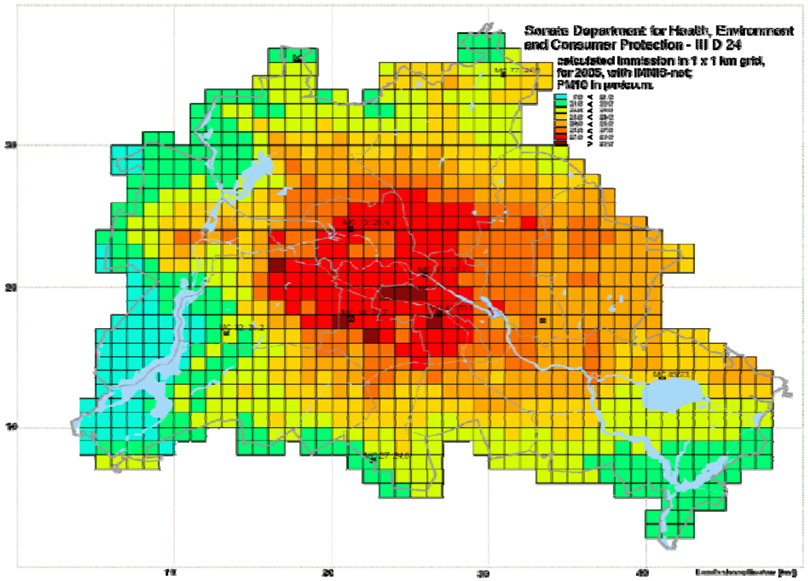
To get a good spatial resolution, modeling may be used

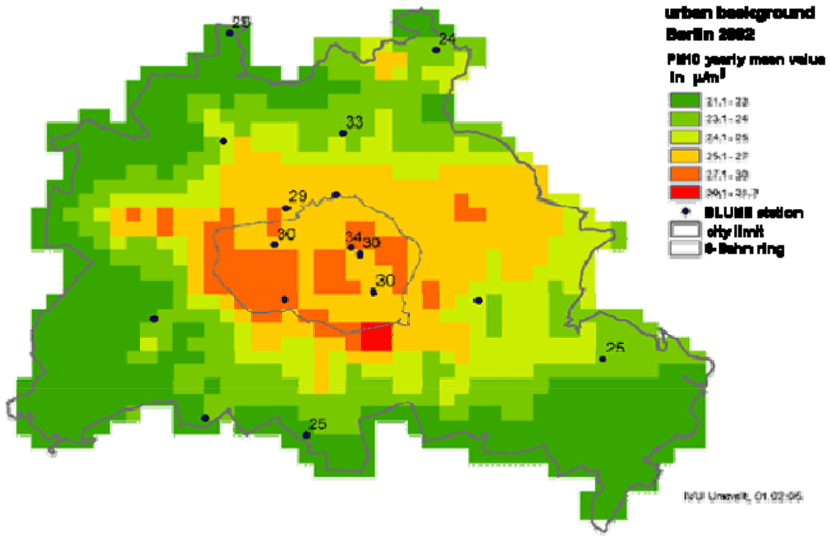
Dispersion models have been developed
as well as statistical models, the so-called
Land Use Regression Models
Recent attempts to use remote sensing data are on-going

These may be very useful, provided they are validated.
For the validation process, measurements are needed.

Air Pollution Monitoring Technologies for Urban Areas

For the study of long-term effects a fine spatial resolution is needed (e.g. measurements in various areas within a city, complemented by appropriate models to downscale to every point within an area)



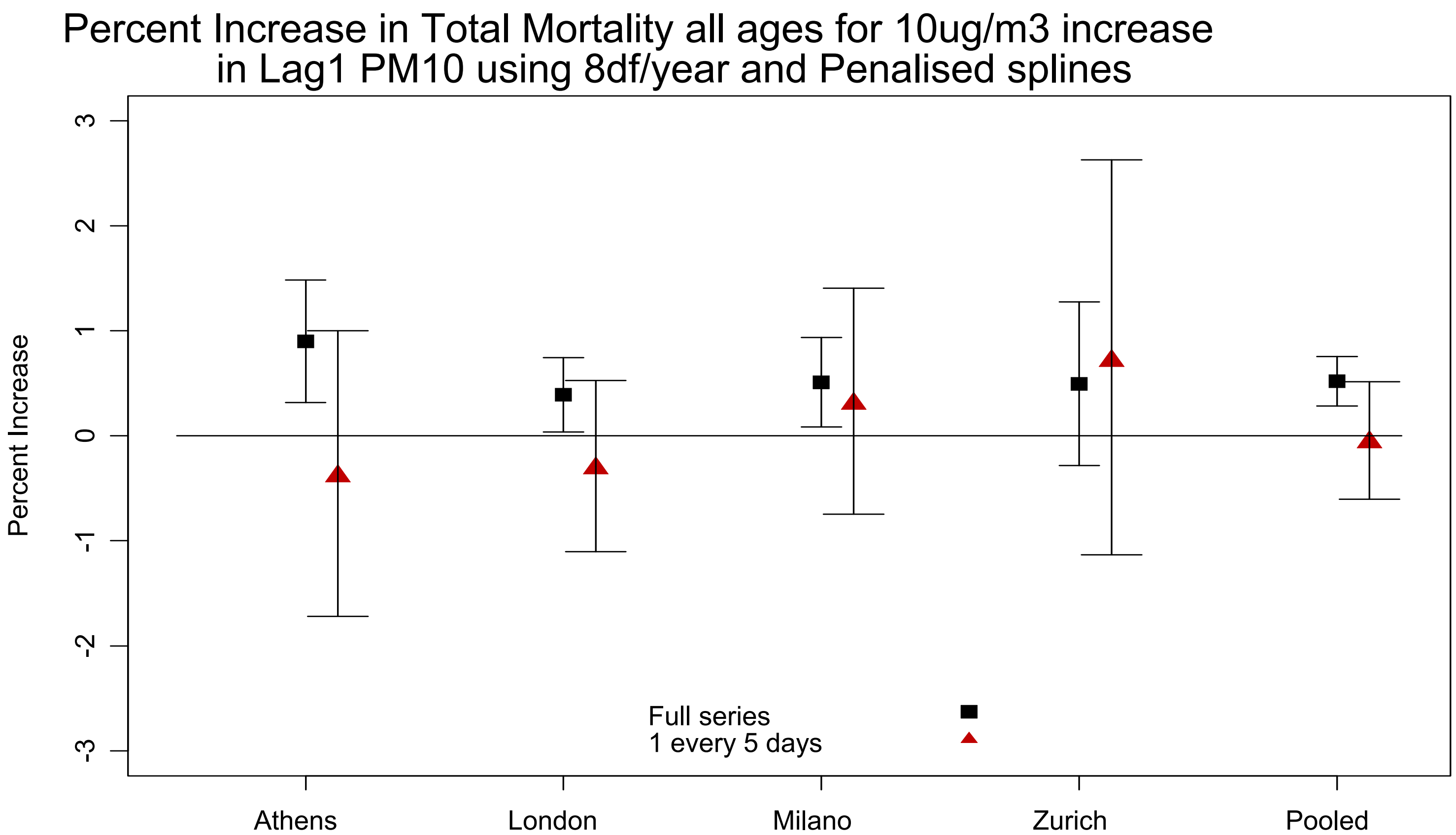


Data requirements for short term studies are more difficult to meet

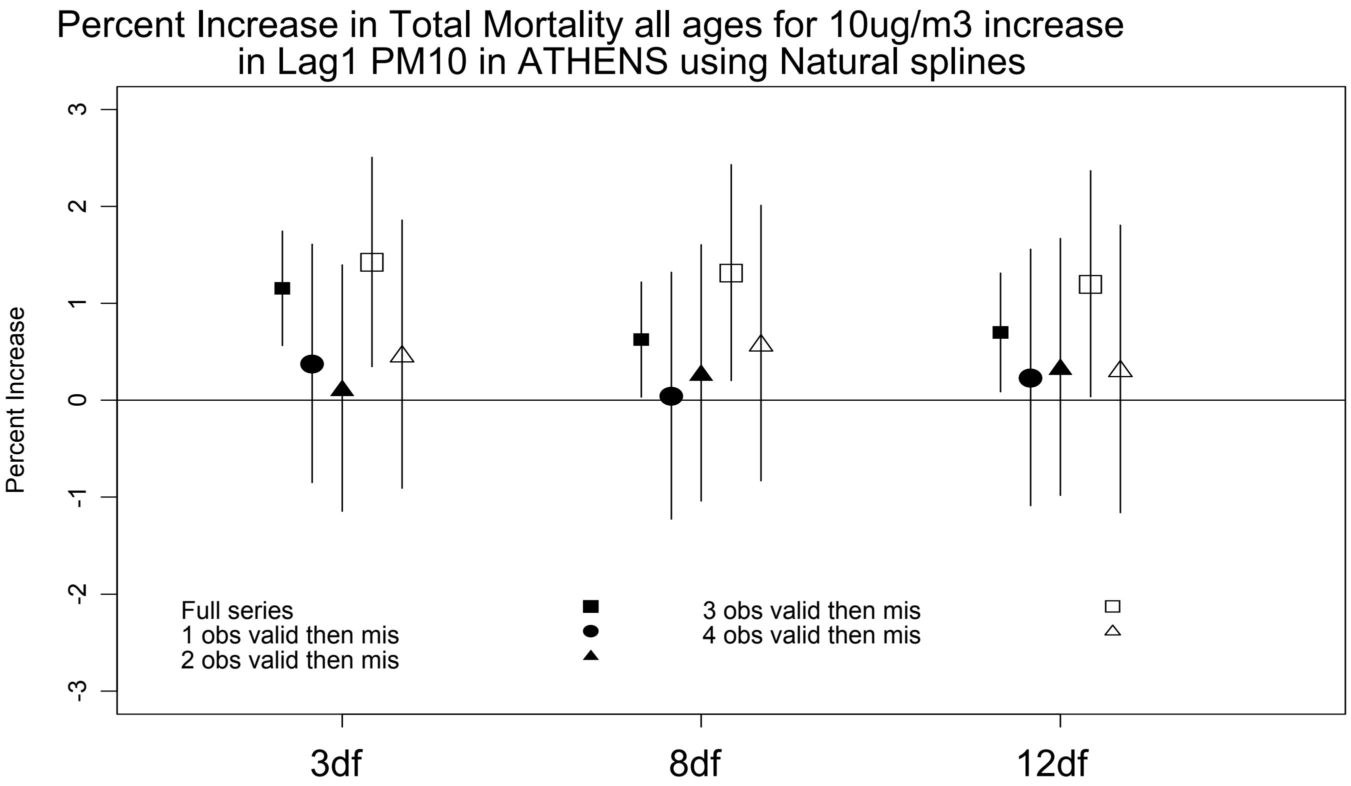
Thus e.g. in the US and Canada several monitors only measure PM every 6th or every 3rd day.

In the framework of the EU-North American collaborative project APHENA we investigated the consequences of not having daily values And unfortunately the findings suggest that daily values are needed.

Investigation of the consequences of having measurements on one out of six days



Investigation of the consequences of having measurements on one out of six days



Some of today's open questions in specifying the health effects of air pollution are:

- Which physical and chemical PM characteristics are the most important for human health?

- Are PM from various sources different in terms of their health effects?

- How (i.e. where and when) do people get exposed?

- Is there interaction between the various aspects of pollution and/or between these and socioeconomic, climatic and other factors, in shaping the health effects?

To answer these questions specific measurement needs arise

- Measurements (on the exposures of interest) with time and spatial resolution.

- Measurements in microenvironments

- Personal measurements

- Data on population time-activity patterns

Data is now available from specific project campaigns

- But these data are fragmented in time and space
- They are not easily comparable
- They are often not possible to combine to yield powerful results
- An recent example illustrates an effort to find and combine data on untrafine particles, where the time periods are in some instances interrupted, the measurement devices are different, the placement of monitors not comparable etc.

What solutions can we propose? (1)

• Clearly the official EU monitoring guidelines and requirements are in a unique position to help yield the necessary exposure data which will form the basis for filling in the knowledge gaps.

•As a first step, more interaction between decision makers and exposure specialists on the one hand and health researchers on the other should be established (e.g. AirMonTech!), that is, a continuous multi-disciplinary interaction at the decision-taking level.

•The target, from the health research point of view, is to assess personal air pollution exposure (for those pollutants or mixtures of pollutants that interest us) with high time and spatial resolution.

What solutions can we propose? (2)

- Not all monitoring systems and sites can provide the same time and space density of information.

- The creation of “supersites” or “special” sites should be considered.

- Mobile measurement units may be employed to complement the fixed site measurements in specific situations, designed in collaboration with health researchers

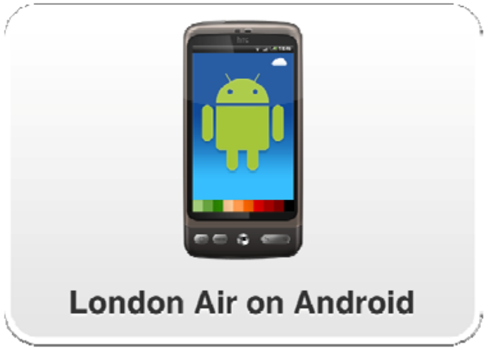
What solutions can we propose? (3)

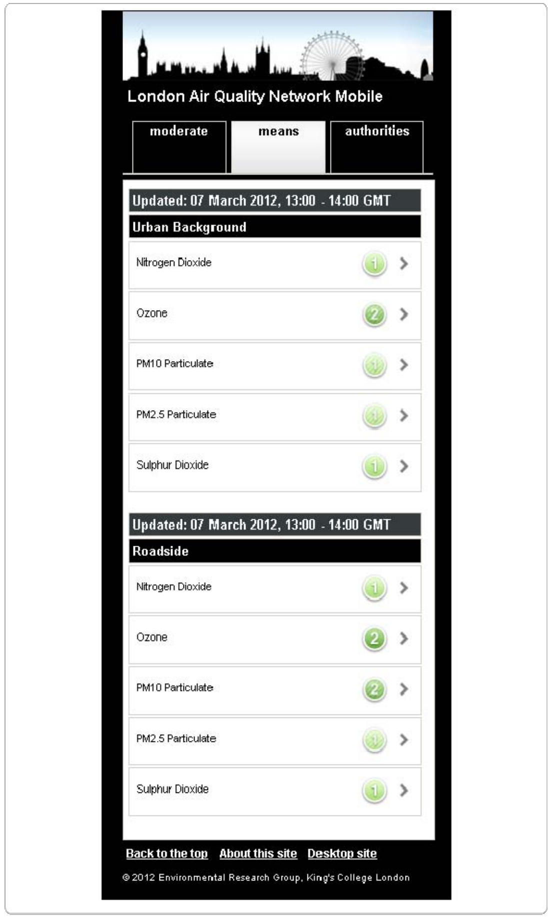
- Exposure studies done ad hoc, but in a coordinated way, in various representative population samples, using smart-phone technology and sensors to record individual location and exposure, can provide input to generate appropriate models for predicting exposure, when combined with routine measurements, to all members of a population.

- Their data can also be used to validate models (e.g. dispersion models or models using remote sensing data).

Furthermore, the collaboration of communities can be achieved and lead to better prevention

- Individuals can be informed about the air pollution conditions, the contribution of the various mobility and activity patterns to their exposure levels and protect themselves better





Thank you!