HEALTH EFFECTS OF AIR POLLUTION – IMPLICATIONS FOR AQ MONITORING

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This presentation:

1) Summary of the results of the WHO – EC project “Review of evidence on health aspects of air pollution - REVIHAAP”

2) Implications for AQ monitoring
About REVIHAAP

• WHO project jointly financed by WHO and EC, managed by WHO/ECEH (Marie-Eve Heroux)
• Evidence review in response to 24 key policy questions from the EC
• Timing: 18 months, Sept 2011 – April 2013
• Steering Advisory Committee (8 experts, 2 meetings, multiple TCs)
• Review of evidence and drafting the answers: 29 experts
• External review: 30 experts
• Two expert meetings (Aug 2012 & Jan 2013)
• Full rationales to be published in June 2013
• Followed by a sister project: “Health risks of air pollution in Europe – HRAPIE” - health risk assessment, emerging issues. (June 2012-Aug 2013)
The scientific conclusions of the 2005 WHO Guidelines about the evidence for a causal link between PM$_{2.5}$ and adverse health outcomes in humans have been confirmed and strengthened and, thus, clearly remain valid.

• New studies on short- and long-term effects;
• Long-term exposure to PM$_{2.5}$ are a cause of cardiovascular mortality and morbidity;
• More insight on physiological effects and plausible biological mechanisms linking short- and long-term PM$_{2.5}$ exposure with mortality and morbidity;
• Studies linking long-term exposure to PM$_{2.5}$ to several new health outcomes (e.g. atherosclerosis, adverse birth outcomes, childhood respiratory disease)
Meta-analysis of the association between long-term exposure to PM$_{2.5}$ and cardiovascular mortality

<table>
<thead>
<tr>
<th>Study</th>
<th>RR (95%CI) per 10 µg/m$^3$</th>
<th>% weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACS (17)</td>
<td>1.09 (1.03, 1.16)</td>
<td>11.22</td>
</tr>
<tr>
<td>WHI (28)</td>
<td>1.76 (1.62, 1.91)</td>
<td>10.86</td>
</tr>
<tr>
<td>NLCSAIR (29)</td>
<td>1.04 (0.90, 1.21)</td>
<td>9.36</td>
</tr>
<tr>
<td>Health Professionals (23)</td>
<td>1.03 (0.83, 1.26)</td>
<td>7.79</td>
</tr>
<tr>
<td>Vancouver cohort (25)</td>
<td>1.07 (0.86, 1.32)</td>
<td>7.59</td>
</tr>
<tr>
<td>US truckers (30)</td>
<td>1.05 (0.93, 1.19)</td>
<td>9.92</td>
</tr>
<tr>
<td>Canadian cohort (33)</td>
<td>1.15 (1.07, 1.24)</td>
<td>10.99</td>
</tr>
<tr>
<td>Rome cohort (39)</td>
<td>1.06 (1.04, 1.08)</td>
<td>11.62</td>
</tr>
<tr>
<td>Six city (37)</td>
<td>1.24 (1.12, 1.37)</td>
<td>10.43</td>
</tr>
<tr>
<td>California teachers (31)</td>
<td>1.07 (0.96, 1.20)</td>
<td>10.21</td>
</tr>
<tr>
<td>Overall (I-squared = 94.1%, p = 0.000)</td>
<td>1.15 (1.04, 1.27)</td>
<td>100.00</td>
</tr>
</tbody>
</table>

NOTE: Weights are from random effects analysis
Mortality and long-term exposure to PM2.5

Results of a cohort study in Rome
(1.3 million adults followed from 2001 to 2010)

PM2.5: 3-dimensional Eulerian model (1x1 km)

c= % increase in risk per 10 µg/m³

- Non-accidental Cause: c=4%
- Cardiovascular Disease: c=6%
- Ischemic Heart Disease: c=10%

AirMonTech, Brussels 16 May 2013
Carotid artery wall thickness (risk of atherosclerosis) and long-term PM$_{2.5}$ exposure

Heinz Nixdorf RECALL study, Ruhr region, Germany

AirMonTech, Brussels 16 May 2013

Bauer et al, JACC 2010
Mortality and long-term PM2.5 exposure
Results of a Canadian cohort study (2.1 million adults, 1991-2001)

PM2.5 estimated from satellite observations + monitoring
• Both short term (such as 24-hour average) and long term (annual means) exposure to PM$_{2.5}$ affect health. (A3)

• Maintaining independent short-term and long-term limit values for ambient PM$_{10}$ in addition to PM$_{2.5}$ to protect against the health effects of both fine and coarse particles is well supported. (A4)

• In the absence of a threshold and in light of linear or supra-linear risk functions, public health benefits will result from any reduction of PM$_{2.5}$ concentrations whether or not the current levels are above or below the limit values. (A5)
REVIHAAP: selected conclusions on PM (A2)

• Black carbon, secondary organic aerosols, and secondary inorganic aerosols may provide valuable metrics for the effects of mixtures of pollutants from a variety of sources. (A2)

• Short-term exposures to coarse particles (including crustal material) are associated with adverse respiratory and cardiovascular health effects, including premature mortality. (A2)

• …
REVIHAAP: selected conclusions on PM (A2)

• There is increasing, though as yet limited, epidemiological evidence on the association between short-term exposures to ultrafine (<0.1 µm) particles and cardiorespiratory health, as well as the health of the central nervous system.

• Clinical and toxicological studies have shown that ultrafine particles (in part) act through mechanisms not shared with larger particles that dominate mass-based metrics, such as PM$_{2.5}$ or PM$_{10}$.
REVIHAAP: selected conclusions on ozone (B1)

- New evidence for an effect of long-term exposure to ozone on:
  - respiratory (and cardiorespiratory) mortality (ACS study);
  - mortality among persons with potentially predisposing conditions (COPD, diabetes, congestive heart failure, and myocardial infarction);
  - asthma incidence, asthma severity, hospital care for asthma and lung function growth.
Long term O3 exposure and risk of death due to respiratory causes
ACS cohort of 448 thousand adults followed for 18 years

RR per 10 ppb = 1.040 (95% CI 1.010 - 1.067)
(2-pollutant model with O3 and PM2.5)
Risk of asthma hospital admissions in children and mean O3 in 1995-1999

Lin et al, EHP 2008
REVIHAAP: selected conclusions on ozone, cont.

- Adverse effects of exposure to daily ozone concentrations (maximum daily 1-hr or 8-hr mean) on:
  - all-cause, cardiovascular and respiratory mortality;
  - respiratory and cardiovascular hospital admissions, after adjustment for the effects of particles (PM$_{10}$).

- The evidence for a threshold for short term exposure is not consistent, but where a threshold is observed, it is likely to lie below 45 ppb (90 µg/m$^3$) (max 1-hr). (B2)
## Associations between short-term exposure to ozone and mortality and hospital admissions in European cities in the APHENA study

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Per cent increase in deaths/admissions (95% CI) per 10 µg/m³ increment in daily maximum 1-hour ozone concentrations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Single pollutant</strong></td>
</tr>
<tr>
<td>All-cause mortality a</td>
<td>0.18 (0.07–0.30)</td>
</tr>
<tr>
<td>Cardiovascular mortality: 75 years and older a</td>
<td>0.22 (0.00–0.45)</td>
</tr>
<tr>
<td>Cardiovascular mortality: younger than 75 years a</td>
<td>0.35 (0.12–0.58)</td>
</tr>
<tr>
<td>Respiratory mortality b</td>
<td>0.19 (-0.06–0.45)</td>
</tr>
<tr>
<td>Cardiac admissions: older than 65 years a</td>
<td>-0.10 (-0.46–0.27)</td>
</tr>
<tr>
<td>Respiratory admissions: older than 65 years b</td>
<td>0.19 (-0.28–0.67)</td>
</tr>
</tbody>
</table>

$^a$ lag 0-1 results; $^b$ lag 1 results  

Katsouyanni et al 2009
New studies document associations between day-to-day variations in NO₂ and variations in mortality, hospital admissions, and respiratory symptoms;

New studies showing associations between long-term exposure to NO₂ and mortality and morbidity;

Both short- and long-term studies have found these adverse associations at concentrations that were at or below the current EU LV (= WHO AQG);

The associations between NO₂ and short-term health effects in many studies remain after adjustment for other pollutants (including PM₁₀, PM₂.₅, black smoke).

... it is reasonable to infer that NO₂ has some direct effects.

No evidence to suggest changing the averaging time for the short-term EU limit value (1-hour) (D1)
Mortality and long-term exposure to NO2

Results of a cohort study in Rome (1.3 million adults followed from 2001 to 2010)

NO2 estimates: Ogawa samplers in 78 sites, 1-week in Feb, May, Oct 2007 + LUR model

c= % increase in risk per 10 µg/m³

Non-accidental Cause

Cardiovascular Disease

Ischemic Heart Disease

AQG & EU LV

AirMonTech, Brussels 16 May 2013
REVIHAAP: selected conclusions on health risks of proximity to roads (C1):

- Elevated health risks associated with living in close proximity to roads is unlikely to be explained by PM$_{2.5}$ mass;
- Current evidence does not allow discernment of the pollutants or pollutant combinations that are related to different health outcomes although association with tail pipe primary PM is increasingly identified;
- Toxicological research indicates that non-exhaust pollutants could be responsible for some of the observed health effects.
REVIHAAP Conclusions

Considerable amount of new scientific information on health effects of PM, O₃ and NO₂ observed at levels commonly present in Europe, has been published in the recent years. It:

- supports the scientific conclusions of the WHO Air Quality Guidelines updated in 2005;
- indicates that the effects can occur at air pollution concentrations lower than those serving to establish the 2005 Guidelines;
- provides scientific arguments for the decisive actions to improve air quality and reduce the burden of disease associated with air pollution in Europe.
This presentation:

1) Summary of the results of the WHO – EC project “Review of evidence on health aspects of air pollution - REVIHAAP”

2) Implications for AQ monitoring
   - For assessment of exposure in epidemiological studies
   - For assessment of impacts of air pollution on population health
REVIHAAP: Critical data gaps (A7/C9) – selected conclusions on exposure assessment in epidemiological studies

- More collaboration is needed between health and atmospheric science both for complex monitoring and modeling, especially for exposure of complex mixtures with strong spatial and temporal variability.

- More monitoring is needed, both in regular way and into projects in coordination with health specialists. The use of supersites to perform simultaneous studies using the same monitoring and health evaluation approaches across Europe is strongly suggested. These studies should be done with a multi-pollutant approach.
Spatial variability of PM2.5 and NO2 in Europe: ESCAPE study

% of variance explained by within area variability:
PM2.5: 19%
PM2.5 absorbance: 52%
NO2: 60%

Eeftens et al, 2012; Cyrys et al, 2012
Spatial variability of PM2.5 and NO2 in Europe: ESCAPE study

NO2: 3 areas out of 36

PM2.5: 3 areas out of 20

Eeftens et al, 2012; Cyrys et al, 2012
Available measured (and estimated from PM10 measurements) annual (2005) average PM2.5 concentrations

Brauer et al, Atm Sc & Tech 2012
Estimated 2005 annual average PM$_{2.5}$ concentrations used for GBD 2010 project

The PM2.5 estimates are generated from the grid cell average of SAT and TM5 and calibrated with a prediction model incorporating surface measurements.

Brauer et al, Atm Sc & Tech 2012
Years of life lost due to PM – GBD 2010 project

3.2 million deaths attributable to PM2.5 globally in 2010

Europe

AirMonTech, B
Percent of all deaths attributable to PM in Europe, 1990 and 2010

GBD 2010 project

- Population weighted PM2.5 (µg/m³)

- Literature sources:
  - Brauer et al, EST 2011

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Conclusions on AQ monitoring

1) Monitoring for research on health effects of air pollution:
   • Assessment of exposure to mixtures;
   • Sufficient spatial resolution;
   • Introduction of new parameters with simultaneous assessment of “old” indicators of pollution.

2) Monitoring for health impact assessment
   • Fusion of monitoring, modelling and remote sensing;
   • Simple methods for monitoring in low-resource locations;

Thank you