Chronic pulmonary effects of ambient nano-PM: Lessons learned from PM

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Life-time course of lung function (e.g. forced expiratory capacities such as FEV1 and FVC)

100% normal at age 20

Disability

Death

0 20 80 Age

FEV1 theoretical max.

100%

Air pollution and Reduced growth phase

0 20 80 Age

Life-time course of lung function (e.g. forced expiratory capacities such as FEV1 and FVC)

100% normal at age 20

Disability

Death

0 20 80 Age

Model of chronic diseases with acute exacerbations

Acute effect

Chronic effect

Frailty susceptibility or probability for morbidity & death

Time

Birth

\( T_0 \)

\( t' \)

\( T_d \)

(Age at death)

Cumulative life-time exposure

\( \Delta t \)

\( \Delta t' \)

Morbidity

Death

(modified from National Research Council, 2002)

Air pollution and Reduced growth phase

Early initiation of decline

Reduced growth phase

Accelerated decline

Role of PM?

Focus of the Southern Californian Children's Health Study
Ambient air pollution is associated with the 8-year development of the lung (growth) (Gauderman et al NEJM 2004).

The percentage of 18-yrs old with lung function <80% (FEV1) increased with ambient PM2.5.


Life-time course of lung function (e.g. forced expiratory capacities such as FEV1 and FVC)

100% normal at age 20

smoking

Effect of smoking cessation

Disability

Death

SAPALDIA 1
1991/2
- Address
- Interview
- Forced expiratory
  lung function

Address Updates 95/97/99

SAPALDIA 2
2001/2
- Address
- Interview
- Forced expiratory
  lung function

NO2, SO2, TSP, PM10, Meteo
- Identical protocols
- Same devices
- Comparison test across devices 1991 and 2001

Künzli et al, ERJ 1995; 8:371

**Life-time course of lung function**
(e.g. forced expiratory capacities such as FEV1 and FVC)

100% normal at age 20

Disability
Death

0 20 80 Age

**Annual mean PM10 and expiratory capacity (FVC)**
in the 8 SAPALDIA areas

PM10 annual mean ($\mu g / m^3$) vs. % deviation from predicted

**Important changes between baseline (1990/91) and follow-up (2001/2)**

1. Air quality improved
2. Advancement of exposure assessment science
3. Many subjects changed residence

**Succes of Clean Air Regulations:**
PM$_{10}$ concentrations 1991 - 2002
Downs et al (SAPALDIA Team), NEJM, 2007

PM$_{10}$ annual mean

1991 2002
Gaussian plume dispersion models, using emission registries, meteorology, and secondary processes to model the pollution space for Switzerland
Liu et al, Env Health Perspect 2007

Dispersion model predictions for PM$_{10}$
Liu et al, Env Health Perspect 2007

Distribution of individually assigned "cumulative PM$_{10}$" (concentration x years)
Downs et al, NEJM 2007

Reduced Exposure to PM$_{10}$ and Attenuated Age-Related Decline in Lung Function
Sara H. Downs, Ph.D., Christian Schindler, Ph.D., L-J. Sally Liu, Sc.D., Dirk Keidel, M.A., Lucy Bayer-Oglesby, Ph.D., Martin H. Brutschi, M.D., Ph.D., Margaret W. Gerbase, M.D., Ph.D., Roland Keller, M.D., Nina Keizli, M.D., Ph.D., Philippe Leumebger, M.D., Nicole M. Protel-Henisch, Ph.D., Jean-Marie Tschoopy, M.D., Jean-Pierre Zellerger, M.D, Thierry Roche, M.D, Joel Schwartz, Ph.D., Ursula Ackermann-Lehmann, M.D., M.Sc, and the SAPALDIA Team


Estimated effect of interval exposure (1991-2002) on decline of FEV1
Downs et al, NEJM 2007

Attenuation of lung function decline per 10 ug/m3 reduction in home outdoor PM10 among 2'213 SAPALDIA never smokers
Downs et al, NEJM 2007

<table>
<thead>
<tr>
<th>Effect</th>
<th>Effect</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC</td>
<td>2.2 ml</td>
<td>0.43</td>
</tr>
<tr>
<td>FEV1</td>
<td>4.2 ml</td>
<td>0.06</td>
</tr>
<tr>
<td>FEV1 in %FVC</td>
<td>0.05%</td>
<td>0.18</td>
</tr>
<tr>
<td>FEF25-75</td>
<td>11.3 ml/s</td>
<td>0.03</td>
</tr>
</tbody>
</table>
Life-time course of lung function (e.g. forced expiratory capacities such as FEV1 and FVC)

- 100% normal at age 20
- Air pollution effect
- Disability
- Death
- Effect of air pollution reduction

Ambient air pollution: complex mixture of 100’s of pollutants
Gases: NOx, SOx, Ozone, CO etc.
Particles: various sizes and constituencies

- PM mass
- Homogeneous
- Particulate number
- CO, Carbon
- Heterogeneous

Zhu et al, J Air Waste Manage Assoc, 2002; 52: 1032
From the Southern California Particle Centre

Living close to busy roads is associated with higher asthma prevalence in children
McConnell et al, EHP

Association between traffic-related pollution and new-onset of asthma in adults: evidence from 2009
Modig et al – RHINE Study, ERJ 2009 – on line
Kuenzli et al, SAPALDIA Study, Thorax 2009 (May)
Jacquemin et al, ECRHS , Epidemiology 2009
Research needs summary

- Investigate specific contribution of nano-PM versus other size fractions
- Investigate spatial distribution of nano-PM and its constituents, to be linked to cohort studies
- Understand link between acute respiratory events, early life time exposure, and chronic development of lung pathologies (SAPALDIA 3)
- Understand exogenous and endogenous susceptibility factors (SAPALDIA 3)

SUMMARY

- Ambient air pollution affects lung development in the long term
- Particulate matter play a causal role
- Specific contribution of nano-PM?
- Specific contribution of PM sources?

ESCAPE

European Study of Cohorts for Air Pollution Effects
(consortium PI: Bert Brunekreef, IRAS)
www.escapeproject.eu
25 European partners, 17 countries,
32 existing cohort studies,
>50 cities and regions

WP 4: RESPIRATORY COHORTS (Adults)
PI: Nino Kuenzli

Thank you

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UK1946 Birth Cohort Anna Hansell Diana Kuh
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Within-city contrasts in air pollutants are larger than contrasts between cities

The inability to refuse the null hypothesis may reflect (i) no effect of urban air pollution on lung function or (ii) inherent biases due to the study design. Examples of the latter are lack of individual-level air quality assignment, not quantified within-city contrasts in traffic-related pollution, or the heterogeneity of the studied populations and their urban environments.
formation of PM2.5 largely differ across Europe

Nawrot et al, Atmos Environ June 2009