Particles and Health- Lessons from the SAPALDIA study

Otto Brändli MD, Hömelstrasse 15, CH-8636 Wald/Switzerland; braendli@swisslung.org

The human body had not enough time to adopt to the emissions of the automobile since the first cars drove on Swiss streets, about 100 years ago. Particles in the air are not only reducing the visibility and causing global warming. They are responsible for increased morbidity and mortality, especially among those living near busy roads.

SAPALDIA (Swiss Study on Air Pollution and Lung in Adults)- the Swiss “Framingham”-study- is a multi-center cohort study in eight geographic areas representing the wide range of environmental, meteorological and socio-demographic conditions of Switzerland. It was initiated in 1991, with follow-up assessments in 2002 and actually in 2010/11.

In 1991 a random sample of 9'651 subjects, aged 18 to 60 years, were recruited for a detailed computer-based interview, lung function and allergy testing. In the 2002 follow-up, 8'047 provided health information and blood samples to establish an extensive blood, plasma, serum and DNA bank. In addition, 1'813 subjects aged 50 or older participated in 24h-ECG- monitoring to provide detailed data on parameters of heart rate variability. With the inclusion of cardiovascular endpoints, SAPALDIA is one of the first studies examining effects of long-term exposure to air pollution on cardiovascular health parameters as well. Ongoing studies are focusing on gene-environment interactions, a crucial question to understand why some persons suffer more from the effect of air pollution than others.

The WHO and the European Research authorities have acknowledged the importance of SAPALDIA as one of the very few population-based adult cohort studies in Europe. It is well positioned to address crucial questions of air pollution epidemiology and important environmental health policy-related questions in the coming years.

Due to SAPALDIA, air quality is now a major issue: Poor air quality is affecting 40% of the Swiss population (living in areas with PM10-levels above 20 mcg/m3, the mean annual standard in Switzerland). It is responsible for lower lung function (3% lower vital capacity per 10 mcg/m3 increase of PM10), more respiratory symptoms (30% more cough etc per 10mcg/m3 of PM10), higher blood pressure and pulse and more irregular heartbeats; causing health costs of more than 2 billion SFR and an estimated 3000 premature deaths every year in Switzerland. Thanks to these data, new air quality regulations have been implemented and have led to an attenuated lung function decline and reduced respiratory symptoms since 1991.

The significant association of measured particle mass and vicinity of home and work place to busy roads with the observed health effects in humans as well as experimental data let us strongly advise to measure particle number counts (of fine and ultrafine particles) as well and to do everything possible to filter the air from noxious particles.

Respiratory health effects of traffic related air pollution:

Short-term effects

More premature deaths (0.6 % more per 10 mcg/m3 increase in PM10)

More emergency room visits and hospital admissions for asthma (+1.1 %) and COPD
Long-term effects

More cardiopulmonary and lung cancer deaths (6 % or more per 10 mcg/m3 increase in PM2.5, thus resulting in >3000 premature deaths every year in Switzerland!)

Lower lung function in children and adults

More allergies

More asthma in children living near busy roads

More chronic bronchitis and COPD in adults living near busy roads

More lung cancer (diesel particles are loaded with carcinogens!)

Higher mortality after lung transplantation

Recently published studies have shown that arteriosclerosis, the thickening of the wall of blood vessels, is also more prevalent near busy roads. And symptoms like cough or wheezing are even more pronounced if you live close to a major highway in a mountain valley, the Gotthard highway. Living near busy roads is obviously dangerous: keep a distance of more than 50 up to 200 meters!

If you do research, please apply for the Swiss Aerosol Award: You have to submit your application before August 31, 2011 (see www.swisslung.ch) to my address above.

Finally, Behavior Change is the most difficult part, please support the following suggestions:

1) Clean the air with diesel particle filters for the exhaust and Nanofilters in the vehicle cabin
2) Think first, then drive; walk or bike short distances; use public transportation
3) Use (and produce) the most advanced, non-polluting and fuel-efficient vehicles

If you need more info, you can download from www.ersnet.org/airquality for free a 60 page publication in German, English, French, Italian or Catalan covering this topic, air pollution and health.

Literature (extract)


Laura Perez, Regula Rapp, Nino Künzli: Outdoor air pollution and lung health. Swiss Med Wkly 2010; 140:w13129.


Künzli N et al: “Air quality and health”, more information on air pollution in Europe, the nature of its
effects and the measures that are being (and should be) taken to combat it. Created in conjunction
with the Swiss Tropical and Public Health Institute (Basel, Switzerland) and the Centre for Research in
Environmental Epidemiology (Barcelona, Spain), the booklet is available in English, Italian, Catalan,
French, German and Turkish, available by http://www.ersnet.org/index.php/publications/air-quality-
and-health.html
Particles and Health: Lessons from the SAPALDIA-study

Dieselruss-Nanopartikel (45‘000-fach vergrössert)

braendli@swisslung.org
Why the particles?
Smog = smoke (particles) and fog (water droplets)
Visibility of Urirotstock (distance 57 km) from Swiss Meteo, Zürich

Days per year

125 (Tage pro Jahr)
100
75
50
25

1880 1900 1920 1940 1960 1980 2000
Tambora, Simbawa, Indonesia, 1815
Volcanic ash from Eyjafjallajökull, Island (Jungfraujoch, 19.4.2010)
Swiss energy consumption 1910-2008 (TJ)
Fraktalgeometrie (Mandelbrot 1924-2010)
More than 1000 particles enter each of our 500 million alveoli every day!
Experimental data:
Climate chambre

human studies division, EPA, Research Triangle Park NC
never smoker

3 month old child living near busy road

smoker
Experimental data: SAPALDIA (Swiss cohort study on Air Pollution and Lung Disease in Adults)
SAPALDIA Study Design
SAPALDIA 1991-2011: methods

**SAPALDIA 1**
- interview
- lung function
- methacholine
- skin prick test
- IgE
- exhaled CO

9651 (Age 18-60)

**SAPALDIA 2**
- interview
- lung function
- methacholine
- biobank
- IgE
- exhaled CO
- heart rate var.
- blood pressure

8047 (Age 28-70)

**SAPALDIA 3**
- interview
- lung function (pre&post bronchodilation)
- biobank (DNA/RNA/Blood)
- heart rate variability
- carotid Intima Media Thick.
- pulse wave velocity
- blood pressure
- W-H-ratio/body shape/body Impendence
- clinical outcomes (registry linkage)
- off-spring study

NO2
TSP
Ozone
CO
SO2
Meteo
Dispersion

1991
2002
2010/11

PM$_{10}$
PM$_{2.5}$
SAPALDIA Research Potential

- Lung function
- Symptoms BHR
- CV-parameters: BP, HRV, PWV, CIMT, symptoms

not personally modifiable exposures

- genetics
- gender
- air pollution
- socioeconomic status

effect modification/life style

- blood markers
- smoking
- nutrition
- physical activity
- occupation
- obesity markers
- reproductive/hormonal factors
- early life expo

functional parameters

- Respiratory Diseases
  - COPD
  - Asthma
  - Lung cancer

- Cardiovascular Diseases
  - Ischemic HD
  - Heart failure

- Other Chronic Diseases

- early life exposure
- mortality

diseases/death
SAPALDIA: participants

SAPALDIA 1 - 1991

- Basel
- Aarau Wald
- Davos
- Lugano
- Montana
- Geneva
- Payerne

9,651 participants, age 18-60

Geo-coding of home addresses at time of S1 and S2 examination

SAPALDIA 2 - 2002

- Basel
- Aarau Wald
- Davos
- Lugano
- Montana
- Geneva
- Payerne

8,047 participants, age 29-71
40% of the Swiss population breath air with PM10 higher than 20 mcg/m³, the Swiss annual mean standard!
Air quality is now a major issue in Switzerland, leading to:

- **Lower lung function**
  (-3% per 10 mcg/m³ increased PM10)
- **More respiratory symptoms**
  (+30% per 10 mcg/m³ of PM10)
- **Higher blood pressure and pulse, more irregular heart beats**
Lower lung capacity (FVC) with increasing PM10-concentrations.
...and more children coughing!
(SCARPOL; schoolchildren studied 1992/93)

4500 schoolchildren, 1., 4. und 8. class

% cough

PM10 annual mean µg/m³

Braun-Fahrländer 1997
Swiss Clean Air Regulations result in lower PM10

(Downs, New Engl J Med 2007; 357:2338-)
and less mean annual decline of lung function (FEV1)
Life-time course of lung function
(e.g. forced expiratory capacities such as FEV1 and FVC)

100% normal at age 20

Air pollution effect

Effect of air pollution reduction

Disability

Death
SAPALDIA: results (2)

Better air quality thanks to clean air regulations:
• attenuates the lung function decline,
• reduces respiratory symptoms
• and correlates with the onset of asthma in never-smokers

Some population segments are more vulnerable
by genetic traits, workplace or societal influences
(for example children, smokers, obese, asthmatics)
Summary: respiratory health effects of traffic related air pollution

- **Short-term**
  - More deaths (0.6% per 10 mcg/m^3^ increase in PM10)
  - More emergency room visits and hospitalisations for asthma

- **Long-term**
  - More cardiopulmonary and lung cancer deaths (6% per 10 mcg/m^3^ increase in PM2.5, amounts to >3000 premature deaths every year in Switzerland!)
  - Lower lung function in children and adults
  - More allergies
  - More asthma in children living near busy roads
  - More chronic bronchitis and COPD in adults living near busy roads
  - More lung cancer (diesel particles are carcinogens!)
  - Higher mortality after lung transplantation .....
More coronary artery disease living near busy roads (calcifications)

Daten von 4494 Personen von 45-75 Jahren Ruhrgebiet, Deutschland
Hoffmann Circulation 2007
More cough and wheezing near Gotthard highway

Hazenkamp-von Arx; Environ Health 2011; 10:13
<table>
<thead>
<tr>
<th>particle size limits deposition</th>
<th>ultrafine «nano» particles PM 0.1</th>
<th>«fine» PM 2.5</th>
<th>„coarse“ particles PM 10</th>
<th>visible dust</th>
</tr>
</thead>
<tbody>
<tr>
<td>diameter (µm)</td>
<td>-0.1 (-100 nm)</td>
<td>0.1-2.5</td>
<td>2.5-10</td>
<td>&gt;10</td>
</tr>
<tr>
<td>deposition</td>
<td>alveoli (heart, brain)</td>
<td>alveoli bronchi</td>
<td>bronchi</td>
<td>nose, throat</td>
</tr>
<tr>
<td>clearance by</td>
<td>macrophages</td>
<td>macrophages, cilia</td>
<td>muco-ciliary escalator</td>
<td>cough, sneeze, swallow</td>
</tr>
<tr>
<td>for example</td>
<td>viruses, diesel-particles</td>
<td>soot</td>
<td>bacteria, mucus droplets</td>
<td>pollen</td>
</tr>
<tr>
<td>health problems caused</td>
<td>pneumonia, cardiac disease, death</td>
<td>alveolitis COPD</td>
<td>bronchitis</td>
<td>rhinitis</td>
</tr>
</tbody>
</table>
Measure particle number concentration
not particle mass:
10 mcg PM 2.5 =
(Oberdörster 1994)

<table>
<thead>
<tr>
<th>diameter nanometer</th>
<th>number /cm³</th>
<th>surface area microm²/cm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>2,400,000</td>
<td>3016</td>
</tr>
<tr>
<td>500</td>
<td>153</td>
<td>120</td>
</tr>
<tr>
<td>2500</td>
<td>1</td>
<td>24</td>
</tr>
</tbody>
</table>
Living near busy roads is dangerous!
Elemental carbon in a highway-tunnel (Gubrist)
Particle number/cm³
(annual mean, NABEL 2010, preliminary data)

3 meters from highway
Swiss fleet 2010: 27% diesel, 44% without DP-filter!
Lüftung/Klimaanlage im Innen-Umluft-Modus: verschmutzte Außenluft gelangt nicht in den Auto-Innenraum.

Filtersystem reinigt verschmutzte Außenluft und leitet saubere Luft in den Auto-Innenraum.

Tag ohne (27.10.2010) und mit (25.10.2010) Filter

<table>
<thead>
<tr>
<th>Zeit (sek)</th>
<th>Konzentration (Partikel/cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>08.00 h</td>
<td>5000</td>
</tr>
<tr>
<td>09.00 h</td>
<td>35000</td>
</tr>
<tr>
<td>10.00 h</td>
<td>15000</td>
</tr>
<tr>
<td>11.00 h</td>
<td>10000</td>
</tr>
<tr>
<td>12.00 h</td>
<td>5000</td>
</tr>
<tr>
<td>13.00 h</td>
<td>8000</td>
</tr>
<tr>
<td>14.00 h</td>
<td>45000</td>
</tr>
<tr>
<td>15.00 h</td>
<td>20000</td>
</tr>
<tr>
<td>16.00 h</td>
<td>10000</td>
</tr>
<tr>
<td>17.00 h</td>
<td>5000</td>
</tr>
</tbody>
</table>

Mittelwert
Ohne Filter: 20400 cm³
Mit Filter: 4600 cm³
Swiss Aerosol Award 2011

The Swiss Lung Foundation has established an annual award of 10’000 CHF for the best scientific publication in the field of international Aerosol research

- the work should come from a Swiss university, clinic or research institute.
- The manuscript can be written in German, French or English and must either be accepted for publication or published in a peer-reviewed journal since Jan 1st 2011

The documents should be submitted by August 31 to Dr. med. Otto Brändli
Hömelstrasse 15, 8636 Wald
braendli@swisslung.org
Behavior Change is the most difficult!

1) think first, then drive
2) walk or bike short distances
3) use public transportation
4) or use (and produce) the most advanced, non-polluting and fuel-efficient vehicles
Luftverschmutzung und Gesundheit.

Authors: Nino Künzli, Laura Perez, Regula Rapp.