Is It Traffic-Related Air Pollution or Traffic Noise, or Both?

Barbara Hoffmann
University of Düsseldorf

HEI Annual Conference
Denver, 2016
Traffic exposure and cardiovascular disease

Hoffmann et al. 2007

HEI annual conference 2016, Denver

Barbara Hoffmann
## Traffic and blood pressure in children

<table>
<thead>
<tr>
<th>Exposure</th>
<th>Estimated change in systolic pressure</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public transport near schools(^a)</td>
<td>1.328(^b)</td>
<td>0.073-2.582</td>
</tr>
<tr>
<td>Public transport near homes(^a)</td>
<td>0.719</td>
<td>-0.474-1.912</td>
</tr>
</tbody>
</table>

Public transport near schools and near homes: 2 mmHg

*Paunovic et al. Noise and Health 2013*
Traffic and cognitive function

Ranft et al. Environmental Research 2009
Traffic exposure
— two important pollutants

NOISE

Air pollution
## Shared health effects

<table>
<thead>
<tr>
<th>Health Outcome</th>
<th>Transportation noise</th>
<th>Traffic-related air pollution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Cardiovascular disease</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Cerebrovascular disease</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Respiratory disease</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>Neurodevelopment in children</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Neurocognition in adults</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Sleep Disturbance</td>
<td>X</td>
<td>(-)</td>
</tr>
<tr>
<td>CVD risk factors</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Depression</td>
<td>X</td>
<td>-</td>
</tr>
</tbody>
</table>
Shared biological pathways (CVD)

Adapted from Münzel et al. EHJ 2014
Fundamental differences

1) Subjective perception
   – Noise vs. air pollution
   – Context, noise sensitivity -> annoyance -> behaviour

2) Determinants of spatial patterns

3) Determinants of personal exposure

4) Threshold

5) Different exposure sources
1. Are the effects independent?
2. What is the degree of confounding between the two exposures?
3. Do noise and air pollution interact?
Independence of effects

CHD Mortality in Vancouver, N=445,868

Gan et al. AJE 2012
Subclinical atherosclerosis

Thoracic aortic calcification (TAC)
non-contrast Cardio-CT

Takasu et al. Am Heart J 2008
Air pollution, noise and TAC

<table>
<thead>
<tr>
<th>Pollutant (IQR)</th>
<th>Crude Model</th>
<th>Main Model Adjusted</th>
<th>Two Exposure Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PM$_{2.5}$</strong> (2.4 µg/m$^3$)</td>
<td>26.5 (12.8-41.8)</td>
<td>19.5 (7.9-32.4)</td>
<td>18.1 (6.6-30.9)</td>
</tr>
<tr>
<td><strong>PM$_{10}$</strong> (4.0 µg/m$^3$)</td>
<td>19.6 (6.2-34.7)</td>
<td>11.6 (0.4–24.1)</td>
<td>9.4 (-1.8–21.9)</td>
</tr>
<tr>
<td><strong>L$_{den}$</strong> (per 5 dB(A))</td>
<td>2.5 (-3.9-9.4)</td>
<td>2.5 (-3.3-8.6)</td>
<td>1.9 (-3.8-8.0)</td>
</tr>
<tr>
<td><strong>L$_{night}$</strong> (per 5 dB(A))</td>
<td>5.5 (1.0-10.1)</td>
<td>4.6 (0.7-8.7)</td>
<td>3.9 (0.0-8.0)</td>
</tr>
</tbody>
</table>

Kälsch et al. EHJ 2013
Basic Questions

1. Are the effects independent?
2. What is the degree of confounding between the two exposures?
3. Do noise and air pollution interact?
Degree of confounding ...

• **Differs between study** i.e. for hypertension:
  Kluizenaar 2007 positive confounding up to 10%
  Babisch 2014 negative confounding of appr. 30%

• **Differs between outcomes in same study**
  i.e. Beelen 2009:
  Cardiac dysrhythmia mortality 0%
  Ischemic heart disease mortality 13%

• **Might differ according to area and spatial unit**
  i.e. Fecht 2015:
  Within neighborhoods of appr. 1600 inhabitants (London) Spearman’s rho 0.01-0.87

• **No clear patterns so far (correlation, type of study, quality of exposure assessment)**
  i.e. Tétreault 2013, Foraster 2013
Confounding

Possible confounding pathway

Residential noise exposure

Road traffic

Determinants of noise

Determinants of air pollution

Residential AP exposure

Health effect

?
Long-term traffic noise

EU Directive; 2002/49/EC, input variables

- Topography, Buildings, Noise barriers
- Street axis, Vehicle-type specific traffic density
- Speed limit, Street surface

→ most exposed facade
Spatial distribution, London
Fecht et al. Env Int. 2016

Average and range of median correlations increase with decreasing size of spatial unit:

- **Spatial scale**       **rho**
  - Greater London       0.51
  - London Boroughs      0.61
  - Neighborhood         0.69
Correlation of noise x air pollution
Girona, Spain N=1,926

Further determinants
Characteristics of housing (type of window, room orientation, etc.)
Subjective perception, noise sensitivity
Personal behaviour
→ residential/personal exposure

<table>
<thead>
<tr>
<th>Variable</th>
<th>Outdoor NO₂</th>
<th>Outdoor $L_{\text{night}}$</th>
<th>Outdoor $L_{\text{night}}$ at façade</th>
<th>Indoor $L_{\text{night}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outdoor annual average NO₂ (µg/m³)</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outdoor $L_{\text{night}}$ [dB(A)]</td>
<td>0.75</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outdoor $L_{\text{night}}$ at bedroom façade [dB(A)]</td>
<td>0.39</td>
<td>0.55</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Indoor $L_{\text{night}}$ [dB(A)]</td>
<td>0.23</td>
<td>0.35</td>
<td>0.78</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Foraster et al. EHP 2014
Hypertension: Noise and air pollution

<table>
<thead>
<tr>
<th>Models $^b$</th>
<th>Hypertension [OR (95% CI)]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$L_{\text{night}}$</td>
</tr>
<tr>
<td><strong>Outdoor model $^c$</strong></td>
<td></td>
</tr>
<tr>
<td>Single-exposure</td>
<td>1.18 (1.05, 1.32)**</td>
</tr>
<tr>
<td>Multi-exposure</td>
<td>1.19 (1.02, 1.40)**</td>
</tr>
<tr>
<td><strong>Façade model $^d$</strong></td>
<td></td>
</tr>
<tr>
<td>Single-exposure</td>
<td>1.08 (1.01, 1.15)**</td>
</tr>
<tr>
<td>Multi-exposure</td>
<td>1.07 (1.01, 1.14)**</td>
</tr>
<tr>
<td><strong>Indoor model $^e$</strong></td>
<td></td>
</tr>
<tr>
<td>Single-exposure</td>
<td>1.06 (0.99, 1.13)*</td>
</tr>
<tr>
<td>Multi-exposure</td>
<td>1.06 (0.99, 1.13)*</td>
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Foraster et al. EHP 2014
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Shared biological pathways (CVD)

Adapted from Münzel et al. EHJ 2014
Transportation noise exposure

• Subjective perception
• Social context
• Cognitive and emotional response
• Endocrine system: Hypothalamic-pituitary-adrenal axis

Emotional response does not need high decibels!!
Synergism? Cognitive function in adults
Heinz Nixdorf Recall Study, Germany

*Adjusted for age, sex, SES, alcohol consumption, smoking status, self-reported ETS, any regular physical activity and BMI.

Tzivian et al. submitted
Over-additive effect – Synergism

Verbal fluency

|$D| > |B + C|$
Some answers to basic questions...

1. In most studies, effects persist upon mutual adjustment – independence!
2. Degree of observed confounding varies strongly between studies, outcomes, areas!
3. Synergism of these two environmental exposures biologically plausible, but very little evidence so far!
Conclusions

When investigating health effects from traffic exposure...

• it is essential to include **air pollution and noise** to really understand their mutual role and their interplay in causing adverse health effects!

• And don´t forget another related exposure with strong health effects and similar spatial patterns: **SES**
Thank you very much

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