Defending Public Health Priorities at Times of Scandals and Media Hypes around “Dirty Diesel”

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Prepared for 22. ETH Conference on Combustion Generated Nanoparticles
Wed 20.6.2018  Session Health - 14:20-15:50h - Zürich
Oxides of Nitrogen NOx

NO and NO₂: one unpaired electron
→ highly reactive
→ oxidation agent

Sources: Traffic, domestic heating, industry and the energy sector.
## Terminology of 5 levels of «evidence for causality»:

«not likely» → «inadequate» → «suggestive» → «likely causal» → «causal»

### Short-term Exposure 2008 to 2016

<table>
<thead>
<tr>
<th></th>
<th>2008</th>
<th>2016</th>
</tr>
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<tbody>
<tr>
<td>Respiratory effects</td>
<td>likely causal</td>
<td>causal</td>
</tr>
<tr>
<td>Cardiovascular effects</td>
<td>inadequate</td>
<td>suggestive</td>
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### Long-term Exposure 2008 to 2016

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<tr>
<td>Respiratory effects</td>
<td>suggestive</td>
<td>likely causal</td>
</tr>
<tr>
<td>Total mortality</td>
<td>inadequate</td>
<td>suggestive</td>
</tr>
<tr>
<td>Cardiovascular effects</td>
<td>inadequate</td>
<td>suggestive</td>
</tr>
<tr>
<td>Birth outcomes</td>
<td>inadequate</td>
<td>suggestive</td>
</tr>
<tr>
<td>Cancer</td>
<td>inadequate</td>
<td>suggestive</td>
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Association of home-outdoor estimates of pollutants with new onset of asthma

ONPHEC Study, 1.1 million healthy residents, 1996 – 2012 (Ontario, CAN)
Rome: Mortality associated with long-term NO2 exposure
Conclusions

• NO₂ is a highly reactive gas contributing to the formation of ozone and particulate matter

• Epidemiologic evidence points at health effects associated with NO₂-exposure that can not be attributed to particulate matter alone

• NO₂ has been shown to be causally related to short-term respiratory effects, especially in people with respiratory disease (asthma)

• NO₂ is a well studied and very useful indicator of traffic related air pollution and its health effects

→ Health impact assessments based on NO₂ will provide complementary insights into the health burden of ambient air pollution
Due to manipulations, NO\textsubscript{x}-emissions of diesel vehicles did not decrease «as expected»

AWEL, Zürich

**Diesel vehicle: NO\textsubscript{x}-Emissions, Euro 1 to 6**

![Graph showing NO\textsubscript{x} emissions for different Euro standards from 1987 to 2015.]
Due to manipulations, on-road NO$_x$-emissions of diesel vehicles did not decrease as expected.

AWEL, Zürich

Diesel vehicle: NO$_x$-Emissions, Euro 1 to 6
Decline of ambient NO$_2$ concentrations less strong than predicted...

Swiss NABEL Network (1986-2015)

Health relevance of the «Diesel scandal» is determined by the effects of the «excess NO$_2$» due to NOT REACHING lower levels because of MANIPULATIONS
Two relevant dimensions:

1) Direct health effects of NO$_2$

2) Indirect effects: NO$_2$ contributes to the development of particulate matter and ozone
Can NO2 be used as an indicator for the estimation of the health burden due to air pollution?

YES… but:

• As complementary or sensitivity analyses
• Some “NO2 effects” may overlap with effects of PM2.5 or other markers of air pollution
→ DO NOT ADD UP PM2.5 + NO2 burden!!
1) Direct health burden of NO$_2$

Example for Germany: long-term effects on mortality

(Schneider et al, 2018)

Association between NO$_2$ and cardio-vascular mortality (Cesaroni, 2013)

Distribution of NO$_2$ annual mean

Distribution of population inhabitants per 250x250m$^2$

→ Derivation of population-weighted annual mean concentration:
→ 18.0 µg/m$^3$

3% (95% conf. interval: 1-5%) increase in cardiovascular death per 10 µg/m$^3$ NO$_2$

~6’000 cardio-vascular death per year (1.8% of cardio-vascular mortality)
attributable to NO$_2$ being, on average, at 18 µg/m$^3$ instead of 10 µg/m$^3$ (background reference value)
Health benefits of a reduction of PM$_{10}$ and NO$_2$ exposure after implementing a clean air plan in the Agglomeration Lausanne-Morges

Alberto Castro$^a,*,$ Nino Künzli$^b,c,$ Thomas Götschi$^a$

International Journal of Hygiene and Environmental Health 220 (2017) 829–839

Prevented years of life lost due to improved air quality based on two indicators of pollution

Prevented years of life lost:
- PM$_{10}$: 279
- NO$_2$: 561
Increase in PM$_{2.5}$ (µg/m$^3$) related to «additional NO$_2$-emissions» due to non-compliance with emission standards

**Global estimate**  
*(Anenberg et al, Nature 2017)*  
\[ PM_{2.5} (\mu g \text{ m}^{-3}) \]

**Europe**  
*(Chossière et al, Env Res Letter 2017)*

Related GLOBAL death burden: ~38’000 death per year attributable to «NO$_2$ manipulation»

... or: approximately 1% of global air pollution attributable death (>4 Million per year)
Premature death due to PM$_{2.5}$ and O$_3$ due to NOx emissions of Light-Duty Diesel Vehicles

EU$_{28}$ + Norway + Switzerland (Jonson et al, 2017)

- ~9'400 cases/yr could have been avoided via on-road compliance with EU-regulations
- ~7'500 cases/yr could have been avoided via compliance with U.S. regulations (diesel case have same standards as gasoline cars)

Without manipulation of car makers

Without manipulation of EU policy makers *)

*) i.e. NOT adopting the U.S. emission standards
Bringing science back to NO$_2$ & air quality policy
1. Enforce «best possible fuel quality» globally

NOTE: for e-mobility, «fuel quality» relates to source of electricity!
Globalized standards for fuel quality needed to stop the dirty business of oil traders

Swiss traders blend crudes to derive the «poorest (legally possible) quality» of diesel for Africa

Samples at gas stations contained up to 630 times more sulphur than diesel sold in Europe…!

Sulfur content in diesel fuel
- Switzerland <5 ppm
- EU max. 10 ppm
- «Limits» in many African countries: 1’000-3’000 ppm

Health effects of this «legal» blending strategy are magnitudes larger than effects of «excess NO₂» (due to illegal manipulation)
Science based clean air policies: a SYSTEMS approach to protect public health

1. Enforce «best possible fuel quality» \textbf{globally}

2. Enforce \textbf{existing} EMISSION Standards (Euro VI/6) \textbf{globally}

... beyond NO$_2$ !
Health effects of 30 years promotion of «dirty diesel» are magnitudes larger than effects of «excess NO₂» (due to manipulation)
Very strong reduction in soot emissions due to reaching Euro 6

Euro 1 bis Euro 6 emissions in mg/km)
Strong decline in PM concentrations
Swiss NABEL Network (1986-2015)

Health benefits of policy-driven PM- (including soot!) reductions are magnitudes larger than the «missed benefits» due to «excess NO2» (manipulation)
Globalized emission standards needed → access to «best available technology»

European car makers continue to export / produce / sell diesel cars **without particle filters**!

Health effects of such deals are magnitudes larger than consequences of «excess NO₂» due to manipulation.
1. Enforce «best possible fuel quality» globally

2. Enforce existing EMISSION Standards (Euro VI/6) globally

3. Set & enforce existing science based ambient AIR QUALITY STANDARDS as proposed by WHO globally

... beyond NO₂!
Protect public health – not monitoring stations!

Hamburg manipulations of concentrations at monitoring stations

- The suggested by-passes may cause longer trips → more pollution in the city!
- «older» vehicles will be sold to other countries … → outsourcing of disease and death

→ Irrational policy activism damages health!

In total, 2 (out of 4’000) kilometers of Hamburg streets are closed for trucks (if less then Euro VI)
No scientific evidence to question, relax, or give up any of the science-based air quality standards proposed by WHO!

... such as the following 5 examples (WHO Air Quality Guidline Values)

<table>
<thead>
<tr>
<th>Long-term limits</th>
<th>limit value</th>
<th>Statistical definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulphur dioxide (SO₂)</td>
<td>30 µg/m³</td>
<td>Annual mean</td>
</tr>
<tr>
<td>Nitrogen dioxide (NO₂)</td>
<td>40 µg/m³</td>
<td>Annual mean</td>
</tr>
<tr>
<td>PM₁₀</td>
<td>20 µg/m³</td>
<td>Annual mean</td>
</tr>
<tr>
<td>PM₂.₅</td>
<td>10 µg/m³</td>
<td>Annual mean</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>Short-term limits</th>
<th></th>
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<tr>
<td>Ozone (O₃)</td>
<td>100 µg/m³</td>
<td>8-hr mean</td>
</tr>
</tbody>
</table>
Example Global PM$_{2.5}$ annual mean regulations: only 7 countries comply with WHO guidelines

<table>
<thead>
<tr>
<th>WHO Guideline Value</th>
<th>Afghanistan</th>
<th>Australia</th>
<th>Cameroon</th>
<th>Canada</th>
<th>Iran</th>
<th>Malawi</th>
<th>Switzerland</th>
<th>U.S.A.</th>
<th>Mexico</th>
<th>E.U.</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 µg/ m$^3$</td>
<td>≤10</td>
<td>12</td>
<td>25</td>
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Health effects of EU refusing science-based guideline values of WHO are magnitudes larger than effects of «excess NO$_2$» (due to manipulation)

«standards» do not protect health!

Health effects of EU refusing science-based guideline values of WHO are magnitudes larger than effects of «excess NO$_2$» (due to manipulation)

... since 1.6.2018 😊
1. Enforce «best possible fuel quality» globally

2. Enforce existing EMISSION Standards (Euro VI/6) globally

3. Set & enforce existing science based ambient AIR QUALITY STANDARDS as proposed by WHO globally

4. Address open policy issues with science-based approaches (e.g. PAH’s, secondary organics, UFP etc.)
Conclusions

• DieselGate scandal caused «excess concentrations of NO2»
• Both, the «legal» and the criminal manipulations caused
   additional PM and Ozone pollution
   additional (fully preventable) diseases and deaths

…HOWEVER

• clean air policies must
  • be science-based, rational, and coherent
  • focus on public health, thus…
  • not focus on NO₂ alone nor on diesel cars alone but:
     all types of engines and all combustion sources
     all regulated pollutants, including PM10, PM2.5, Ultrafines, SO2, NO2, O3 …
     Focus on PUBLIC HEALTH, not on «monitoring stations»
     Keep a GLOBAL focus and equity
Thank you very much

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Experimental studies with a few healthy individuals vs. Epidemiologic studies with a lot of participants

For vital capacity (VC), a nonsignificant dependency on exposure concentration was found in the analysis of variance ($p = 0.08$) and in the Kruskal–Wallis test ($p = 0.09$; Fig. 3).
New Review by Atkinson *et al.* on long-term effects of NO$_2$ (Epidemiology 2018)

- **Outcome:** Mortality
- **42 publications on 31 cohort studies** (i.e. longitudinal studies)
- **High heterogeneity of study results** (I-square 67-90%)
- **Effect:** 2% increase in mortality per 10 µg/m$^3$ NO$_2$ (95%-Confidence Interval: 1-3%)
- **→ wide prediction intervals:** -0.01% to 6%
New Review by Atkinson et al. on long-term effects of NO₂ (Epidemiology 2018)

Land-use-regression NO₂ models (exposure)

Area level NO₂ exposure

Combined effect

- Mortality effect estimates similar NO2 and PM2.5
- NO2 effects remain stable also after adjustment for PM2.5
Environmental pollution – the leading cause of premature death (globally)

Landrigan P, Fuller R et al, Lancet Oct 2017

![Graph showing global estimated deaths from various causes]

- Total pollution: Highest number of deaths
- Tobacco smoking: Second highest number of deaths
- AIDS, malaria, and tuberculosis
- Alcohol use
- Malnutrition (child and maternal)
- Road accidents
- Drug use
- War and murder (interpersonal violence, 2015)
- Ebola (2015)
Largest part of global pollution-related deaths are attributed to AIR POLLUTION

Landrigan P, Fuller R et al, Lancet Oct 2017
Overwhelming scientific evidence that compliance with air quality standards proposed by WHO improve health
Schweiz 1980-2016 (NABEL Stationen) - Jahresmittel

PM$_{10}$  SO$_2$  NO$_2$

Science based standards
Zambia death stirs Glencore tensions

GLENCORE is facing fresh accusations over its controversial Zambian copper mine, with locals blaming the death of a politician on the commodity giant’s failure to stop sulphur pollution.

Mufulira District Commissioner Beatrice Mithi collapsed and died after inhaling toxic sulphur dioxide emissions from the nearby Mopani Copper Mine, 73pc-owned.

Funeral of District Commissioner Beatrice Mihti (age 57) – died in SO2-smog cloud from Mopani Copper Mine, in Jan 2014

Kankoyo monitoring station, Mai-Okt 2013

SO2

4000

3000

2000

1000

0

1.Mai

16.Okt

London-smog 1952

Very strong benefits for air quality
(… and public health)

Example:
elemental carbon annual means, Payern, Switzerland
Exposed

Initially without the outcome

Not Exposed

Time passes

Compare Incidence
Trends der Schadstoff-Konzentrationen Schweiz 1980-2016 (NABEL Stationen) - Jahresmittel

Wissenschaftlich begründete Grenzwerte zum Schutz der Gesundheit (gemäß Schweizer Umweltschutzgesetz)