Title: The burden of near-road traffic-related pollution: the example of asthma in children

Name of Author: Laura Perez Grau
Co-Authors: All members of the APHEKOM network and local city partners.
Affiliation: Swiss Tropical and Public Health Institute
Mailing address: Socinstrasse 57, P.O. Box, 4002 Basel-CH
Phone / Fax: 061 284 8395
E-mail: l.perez@unibas.ch

Background
Two important aspects have emerged in recent air pollution epidemiological research. First, numerous studies indicate that air pollution can contribute to the development of chronic pathologies, thus, impacting the incidence and prevalence of chronic disease. Then the evidence of health effects due to near-road concentrations of traffic-related pollution – in particular the ultrafine fraction - is growing fast.

These findings have important implications when estimating the burden of air pollution that include near-road traffic pollution and background air pollution generated from other sources. First, if one assumes that near road traffic-related pollution cause chronic disease, this burden should now be accounted for. Then, if one assumes that air pollution affects both the development of chronic pathologies and its exacerbation, the entire ‘chronic disease career’ that includes all its acute manifestations, ought to be attributed to air pollution no matter what caused the exacerbations.

The evidence of a role of near roadway traffic-related pollution is particularly strong for childhood asthma - the most prevalent chronic disease in children. Children living close to busy roads are more likely to develop asthma whereas urban background pollution is not associated with childhood asthma incidence. Traditional air pollution impact assessments quantified only the burden of acute exacerbations directly associated with acute air pollution exposure.

Objective

We derived the burden of acute exacerbations related to the chronic ‘morbidity careers’ attributed to near-road traffic-related pollution as well as the acute exacerbations attributable to urban background levels of air pollution in 10 European cities, all partners in the Aphekom project (Improving Knowledge and Communication for Decision Making on Air Pollution and Health in Europe). While our main assessment focused on childhood asthma, we expanded the evaluation for another important chronic condition in adults, namely CHD because similar patterns are expected.

Methods
Following an approach recently published\textsuperscript{1,2}, we used an expansion of the Population-attributable fractions (PAF) for evaluating the burden of both chronic and acute effects of air pollution. Figure 1 illustrates the calculation approach. We first estimated among the healthy target population the number of chronic diseases due to near-road traffic pollution (figure 1, [2]) and due to other causes (figure 1, box [3]). Then, episodes of exacerbation of the diseases due to air pollution were further estimated among those for which near road traffic pollution was the cause of chronic disease onset (figure 1, [5]) and among those for which other causes than traffic pollution was the cause of chronic disease onset (figure 1, [6]). The sum of box [5] and [6] is in fact equal to the standard approach to evaluate the acute burden of air pollution but partitioned to distinguish the contribution due to local traffic pollution. We then calculated episodes of exacerbation among those for whom near-road traffic pollution was the cause of chronic disease onset but exacerbations were due to other causes than air pollution (figure 1, [8])—this represents the burden still ignored in other burden evaluations.

Results
Combining traffic density information and population data, we estimated that within the 10 cities included in our analysis, between 14\% and 56\% of the population lives within 75m of busy roads, represented by all streets and roads carrying more than 10,000 vehicles per day (Table 1). Exposure to busy roads was used as a proxy for near road traffic-related pollution. For comparison, the study in Southern California using direct information of residence distance to busy roads, measured that 15\% of children in the study, representative of children in Southern California, were living within 75m of busy roads. This represented 6\% and 9\% of prevalent childhood asthma for two communities in Southern California\textsuperscript{2}. This recent revised estimations showed thus that the asthma burden from traffic-related pollution is substantial and that this has resulted in a considerable under-appreciation of the total burden and costs of air pollution for this disease\textsuperscript{2,3}. The large exposure to near-road traffic related pollution that we estimated for European populations suggests that a large prevalence of asthma and asthma-related diseases may be attributable to near-road traffic population in Europe.

Conclusions
There is now sufficient biological evidence to support mechanistic pathways linking near road traffic-related pollution exposure to chronic diseases, especially for the onset of asthma in children. The findings on the potential morbidity impacts of near road traffic-related pollution may be specifically relevant for Europe where there is a high population density cohabiting with high traffic loads. Policies addressing specifically the concentrations of those near-road pollutants, such as ultrafine particles, could have very substantial benefits for public health.

References


Figure 1. Conceptual approach to derive the attributable impact of air pollution into account traffic exposure as cause for onset of chronic disease as reported in\textsuperscript{1}.
Table 1. Summary of exposure data for the evaluation of near road traffic related pollution burden in 10 cities in Europe

<table>
<thead>
<tr>
<th>City</th>
<th>Total population (Million Habitants)</th>
<th>PM$_{10}$ annual average (ug/m$^3$)</th>
<th>NO$_2$ annual average (ug/m$^3$)</th>
<th>% population within 75m of busy roads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barcelona</td>
<td>1.5</td>
<td>33</td>
<td>36</td>
<td>56%</td>
</tr>
<tr>
<td>Bilbao</td>
<td>0.35</td>
<td>27</td>
<td>29</td>
<td>29%</td>
</tr>
<tr>
<td>Brussels</td>
<td>1.0</td>
<td>29</td>
<td>38</td>
<td>37%</td>
</tr>
<tr>
<td>Granada</td>
<td>0.24</td>
<td>34</td>
<td>31</td>
<td>14%</td>
</tr>
<tr>
<td>Ljubljana</td>
<td>0.27</td>
<td>32</td>
<td>28</td>
<td>23%</td>
</tr>
<tr>
<td>Rome</td>
<td>2.8</td>
<td>37</td>
<td>61</td>
<td>22%</td>
</tr>
<tr>
<td>Sevilla</td>
<td>0.70</td>
<td>41</td>
<td>29</td>
<td>20%</td>
</tr>
<tr>
<td>Stockholm</td>
<td>1.3</td>
<td>17</td>
<td>13</td>
<td>14%</td>
</tr>
<tr>
<td>Vienna</td>
<td>1.7</td>
<td>25</td>
<td>32</td>
<td>36%</td>
</tr>
<tr>
<td>Valencia</td>
<td>0.74</td>
<td>46</td>
<td>51</td>
<td>44%</td>
</tr>
<tr>
<td>All*</td>
<td>10.6 (sum)</td>
<td>32 (mean)</td>
<td>35 (mean)</td>
<td>29% (mean)</td>
</tr>
</tbody>
</table>

*Mean is across cities
The burden of near-road traffic related pollution

The example of asthma in children

Dr. Laura Perez
Chronic Disease Epidemiology
Department of Epidemiology and Public Health
Swiss Tropical and Public Health institute
(Swiss TPH is an associated Institute of University of Basel)
Overview

• Near road traffic-related pollution and asthma in children

• Methodological implications for estimating the morbidity burden due to air pollution

• Case study

• Implications of our findings for policy
Traffic proximity and exposure

Fine particulate matter homogeneously distributed

Ultrafine particles and other primary pollutants distribution depends on the distance to the source

Relative concentration of pollutants

Distance to busy road

Modified from Künzli, 2012
Residential distance to busy roads and childhood asthma

Represents ~30% increase risk of having doctor-diagnosed asthma for children living ≤ 75m

McConnell et al, EHP 2006
Evidence of air pollution effects in childhood asthma

ESTABLISHED:
Background pollution triggers asthma symptoms (i.e. cough at night) among children that have asthma

NEW EVIDENCE:
Near-roadway traffic related pollution may cause the development of asthma

IMPLICATION:
The entire “asthma career“ (any disease linked to having asthma) of any children with asthma attributed to near-roadway traffic related pollution should also be attributed to this exposure
Traditional risk assessment approach
Assumption: air pollution only triggers asthma symptoms (among those that already have asthma)

Total number of exacerbations (i.e. episodes of cough at night)

Attributable to air pollution

Attributable to other factors
Revised risk assessment approach

Assumption: there is causality between near-road traffic pollution and becoming an asthma patient

1) Number of children with asthma
   Attributable to near-roadway traffic pollution

2) Yearly number of exacerbations (i.e. episodes of cough at night)
   Attributable to air pollution
Global Goods Movement and the Local Burden of Childhood Asthma in Southern California

Laura Perez, MS, Nino Künzli, MD, PhD, Ed Avol, MS, Andrea M. Hricko, MPH, Fred Lurmann, MS, Elisa Nicholas, MD, Frank Gilliland, MD, PhD, John Peters, MD, ScD, and Rob McConnell, MD
1) Asthma due to long-term exposure to near road traffic-related pollution, represented by living at proximity of busy roads.

2) Asthma exacerbations (i.e. hospitalization and symptoms) due to exposure to regional air pollutants (NO$_2$ and O$_3$) above levels found in clean communities in Southern Los Angeles.

- Exacerbations among the asthmatic children having asthma due to near-road traffic related pollution
- Exacerbations due to air pollution among all other children with asthma
## Children with asthma attributable to near-roadway traffic-related pollution

<table>
<thead>
<tr>
<th>Community</th>
<th>% of children exposed to busy roads</th>
<th>Cases in % total asthmatic population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long Beach</td>
<td>12.8%</td>
<td>9.2%</td>
</tr>
<tr>
<td>Riverside</td>
<td>14.9%</td>
<td>6.1%</td>
</tr>
</tbody>
</table>
Exacerbations per year
(NO\textsubscript{2} reduction from current levels to background levels found in clean communities in Southern California)

<table>
<thead>
<tr>
<th>Long Beach</th>
<th>Standard approach</th>
<th>Revised approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bronchitis episodes among asthmatics</td>
<td>3,400 (50%)</td>
<td>3,700 (55%)</td>
</tr>
<tr>
<td>Emergency Room visits for asthma</td>
<td>160 (2%)</td>
<td>1,100 (11%)</td>
</tr>
<tr>
<td>Clinic visits for asthma</td>
<td>500 (4%)</td>
<td>1,600 (13%)</td>
</tr>
<tr>
<td>Hospital admissions for asthma</td>
<td>30 (11%)</td>
<td>51 (19%)</td>
</tr>
</tbody>
</table>
### Percentage of population living near busy roads (>10,000 vehicles day) in 10 European cities

<table>
<thead>
<tr>
<th>City</th>
<th>Population (Mio. Hab)</th>
<th>PM$^{10}$ annual average (ug/m$^3$)</th>
<th>% population within 75m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Granada</td>
<td>0.24</td>
<td>34</td>
<td>14%</td>
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<td>0.27</td>
<td>32</td>
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<tr>
<td>Vienna</td>
<td>1.66</td>
<td>25</td>
<td>36%</td>
</tr>
<tr>
<td>Rome</td>
<td>2.81</td>
<td>37</td>
<td>22%</td>
</tr>
</tbody>
</table>
Implications for policy

• Underestimation of overall morbidity burden of air pollution

• Large public health benefits of reducing population exposure to near-road traffic-related pollution (beyond what is currently proposed)

• Need for establishing risk functions for “compound” of relevance for health to improve health impact evaluation (need to understand mixture of pollutants that cause effects)
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Nino Künzli, Swiss Tropical and Public Health Institute, Basel, Switzerland . University of Basel, Basel, Switzerland

Rob McConnell, Keck School of Medicine, University of Southern California, Los Angeles, USA.

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