Air-pollution-dependent changes in the morbidity of children

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Abstract

One of the aims of the studies presented here was to determine the extent to which differing and changing air pollution exposure scenarios are reflected in differences in the prevalences of certain diseases in children. Significant changes in the air pollution burden of the region led to this investigation. Starting off with a very high morbidity of bronchitis, it could be demonstrated that, depending on the outdoor level of SO₂, the morbidity decreased in accordance with decreases in SO₂. On the other hand, indoor air pollution appears to take on more and more the dominant role in case of allergies.

Introduction

Findings of numerous epidemiologic studies suggest an association between the occurrence of health effects and environmental pollution. As far as air pollution is concerned, the research focuses mainly on respiratory diseases and allergies. This is a natural consequence, as the respiratory system is the portal for inhalative substances and allergens entering the organism and the organ system primarily affected [1]. This investigation, for instance, was concerned with the effects of outdoor SO₂ in relation to airway diseases, motor vehicle traffic
emissions to allergies and pseudocroup as well as microbiologic exposure to allergic symptoms. Past and current epidemiologic studies essentially have limitations, i.e., the outcome is confined to an ‘assumed dominant influence’, paying quite often little attention to the actual personal exposure [2]. Yet, personal exposures are marked by numerous possible scenarios, whose potential effects are more distinctly associated with the duration of the exposure.

Aims of the here presented studies:

- the health risks associated with specific air pollution scenarios are determined, based on the analyses of time-budgeted personal exposures of the participating subjects which were collected in cross-sectional epidemiologic studies
- using repeat-cross-sectional studies of the same group of subjects, conducted over an extended period of time, changes in the prevalences under investigation are compared with changing patterns in exposures, should they have occurred (these repeat-cross-sectional studies essentially are two studies following intervention – change in exposure)
- based on changes in exposures, an exposure-dependent pattern of risks is expected to be identifiable. This will provide the evidence for efficacious strategic interventions and should lead to the development of cause-effect related primary preventive steps.

The two dominating exposures are in- and outdoor pollution. Outdoor exposure constitutes, except for local characteristics, emissions from energy-producing industries and road traffic. Indoor air pollution is, because of its person-dependent determinants, much more complicated. Inspite of this, specific activities, such as home renovations, construction-material-dependent pollution, lifestyle behaviours as smoking, etc., do tend to lead to pollution patterns.

Taking the above mentioned into consideration, exposures to pollutants derived from combustion processes (e.g., SO₂, CO, NOₓ, volatile organic compounds [VOCs]) and those typically found indoors (e.g., VOC) play an important role especially from an air pollution control and air hygiene point of view.

With respect to children, investigations into airway diseases and allergies are very important. First, exposures can be associated more easily with the health effects, as children are, in general, less mobile than adults, which limits the range of contributing exposure situations. Secondly, children generally are not subjected to occupational exposures nor do they have developed lifestyles which have their own health consequences. This increases the chance to identify possible risk factors and implement more successfully primary preventive strategies. Moreover, minimizing or avoiding exposures can be assumed to lead more easily to prevention of disease.
Methods

Table 1 presents studies [3] that were conducted between 1993 and 1999 to investigate environmentally influenced airway diseases, allergies and infections:

- **LARS** – Leipzig Allergy High Risk Children’s Study
- **KIGA** – KinderGArten Children’s Study of Allergies and Airway Diseases
- **LISS** – Leipzig Infect, Allergy and Airway Disease Study in Schoolstarters

The study population consisted of children ranging in age from birth to seven years.

Table 1: Overview of the study designs

<table>
<thead>
<tr>
<th>STUDY</th>
<th>new-borns</th>
<th>preschoolers</th>
<th>schoolstarters</th>
</tr>
</thead>
<tbody>
<tr>
<td>KIGA</td>
<td>cohort</td>
<td>cross-sectional</td>
<td>cross-sectional</td>
</tr>
<tr>
<td>LISS</td>
<td>prospective</td>
<td>repeat cross-sectional</td>
<td></td>
</tr>
<tr>
<td>sample size</td>
<td>420</td>
<td>881</td>
<td>2888</td>
</tr>
<tr>
<td>(main) targets</td>
<td>airway diseases, infections and allergies</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Both cross-sectional studies (KIGA, LISS) are based on the same study design. This as well as the temporal shift of 5 years between the LISS and the KIGA study allows a temporal comparison as two studies after intervention in the exposure has taken place.

The epidemiologic data of illnesses and symptoms in these cross-sectional studies are based on parent-elicited questionnaire information. The exposure of each study participant was determined individually, parallel to the clinical and epidemiologic investigations. In light of the expected exposure profiles, this analysis was mainly concerned with the pollutant components, VOCs and SO₂. Previous analyses had identified benzene as a representative indicator for traffic-derived emissions and SO₂ for coal-fired domestic heating [4]. The chemistry-related analyses are described in details elsewhere [5, 6].
Results and discussion

Indoor exposure

Children of the study area were found to spend about 85% of their time indoors. This means, the effective dose is not determined as much by exposures outdoors but rather by exposures indoors. Moreover, the VOC emissions (sumVOC of 26 air pollution relevant VOCs [7]) were found to be 10 times higher indoors compared to outdoors, in some cases even considerably higher than that (Fig. 1).

Similar indoor sumVOC exposure conditions were observed in the KIGA and the LARS studies, even though they were conducted at different points in time, 1993-96 and 1995-1999. This applies not only for the sum concentration (c[sum]_{KIGA}=288 \, \mu g/m^3; \, c[sum]_{LARs}=301 \, \mu g/m^3) but also for the proportional concentrations of single VOC components in the total exposure profile. The similarity in exposure conditions, obviously, was expected to be associated with similar risks, which could be shown with the KIGA and LARS studies.

Depending on human activities, associated with certain exposures (e.g., home renovations, cigarette smoking, cooking), the data of the KIGA study indicated Odds Ratios (OR) for allergic symptoms and infections between 2 and 3. The earlier these exposures (e.g., associated with activities such as home renovations) took place in terms of the development of these children (e.g., age), the more detrimental appear the health effects. This can be concluded from the new-born study LARS (prospective cohort study). Adjusted for a number of confounders (sex, passive smoking, family history of atopy and airway disease, etc.), the VOC-concentration-dependent risks ranged from OR = 1.9 – 6.4 for infections and eczema infantum (Table 2), respectively.

Table 2 : Odds Ratios for different exposures

<table>
<thead>
<tr>
<th>Study</th>
<th>Area</th>
<th>Target</th>
<th>Exposure</th>
<th>Indicator</th>
<th>OR</th>
<th>95%CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>KIGA</td>
<td>Outdoor</td>
<td>bronchitis, infections</td>
<td>heating attributed emissions</td>
<td>SO₂</td>
<td>1.5</td>
<td>1.1 - 2.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>asthma, allergies</td>
<td>traffic attributed emissions</td>
<td>benzene</td>
<td>1.7</td>
<td>1.2 - 2.5</td>
</tr>
<tr>
<td></td>
<td>Indoor</td>
<td>infection</td>
<td>renovations</td>
<td>VOC or VOC-linked activities</td>
<td>1.9</td>
<td>1.1 – 3.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>eczema infantum</td>
<td>renovations</td>
<td>VOC or VOC-linked activities</td>
<td>2</td>
<td>1.1 – 3.7</td>
</tr>
<tr>
<td>LARS</td>
<td></td>
<td>infection²</td>
<td>renovations</td>
<td>VOC or VOC-linked activities</td>
<td>6.4¹</td>
<td>1.2 – 34.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.9</td>
<td>1.1 – 3.5</td>
</tr>
</tbody>
</table>

¹ eczema infantum, age week 7, in low birth weight infants
² infection in the 1st year of life
Fig. 1 Comparison between the indoor and outdoor VOC burden

Outdoor exposure

Analyses of the KIGA study data showed that the two main exposure sources – energy-producing industries and road traffic – were of different health relevance [4]. Whereas domestic heating emissions (indicator $SO_2$) affected bronchitis and infections with an OR = 1.5, the risk to allergies and asthma increased with exposure to traffic-derived pollutants (indicator benzene), OR = 1.7. These results are based only on the cross-sectional KIGA study.

Comparing the KIGA-study results with the LARS-study, similarities in VOC-dependent risks to allergies are observed:

- OR (LARS, renovations) = 2.3
- OR (KIGA, traffic) = 1.7
- OR (KIGA, renovations) = 2.0

Further analyses revealed that the exposure profile determined indoors, was distinctly related to home renovations and very similar to the emission profile found associated with traffic-derived pollutants [8]. This explains the above mentioned similar Odds Ratios.

The lifetime prevalences for bronchitic illnesses of the, on average 7-year old, children of the KIGA and LISS studies are depicted in Fig. 2. Lifetime exposures differed significantly for the two groups (completely different pollution spectra) as a significant reduction in the air pollution level had taken place in-between. The years of birth for the KIGA study population fell between 1987 and 1991,
for the LISS probands between June 1991 and May 1992. Thus, the KIGA-
children’s lifetime, from birth until the start of the study, comprises the years
The occurrence of bronchitic disease, observed in the KIGA study with an
OR = 1.5 and found to be domestic-heating-dependent, is confirmed by the
morbidity development observed during the temporal course of the exposure
from the KIGA to the LISS study periods. As the exposure (indicator component
SO$_2$) decreased, the associated effects (bronchitis) decreased proportionally. This
becomes especially clear when the average concentrations, these children were
exposed to during their lifetime, are considered up to the time of the
investigation (Fig. 2).

![Fig. 2 Exposure dependent morbidity (of bronchitis)](image)

**Conclusions**

Based on the data of all three studies LARS, KIGA and LISS, it can be concluded:
- with regard to the diseases under investigation, special attention should be
  paid to population groups especially at risk, such as children
- among new-born babies, those of low birth weight, are especially at risk
  from air pollution
- critical time periods in the development of a child appear crucial for the
  manifestation of allergic disease
• minimizing or avoiding exposures, identified as risk factors in epidemiologic studies, can lead to a reduction in the occurrence of disease (comparison of bronchitis and exposure KIGA-LISS)
• minimizing or avoiding one source of exposure, when essentially two different exposure sources with same risk associations are present, does not suffice and does not lead to changes in the morbidity (comparison LARS-KIGA-LISS: allergies and exposures to traffic and indoor pollutants from, i.e., home renovations)
• indoor air pollution is increasingly becoming more problematic than outdoor pollution

References