Exposure to highway traffic exhaust and its impacts on childhood respiratory health in trans-Alpine highway valleys

Regina Ducret-Stich, Martina Ragettli, Charlotte Braun-Fahrländer, Alex Ineichen, Harish C. Phuleria, Christian Schindler, L.-J. Sally Liu

Background and Objective

Although trans-Alpine highway traffic exhaust is the major source of air pollution along the highway valleys of the Alpine regions, no studies have examined health impacts from such exposure due to limited population and pollution measurements. Our previous study showed significant associations between respiratory symptoms and residential exposure to highway traffic in adults. This study is focusing on children living in the Swiss Alpine highway corridor.

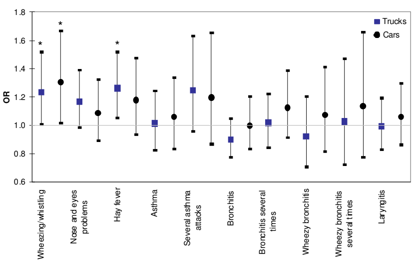
Methods

Between 2007 and 2008, 2’305 schoolchildren (ages 7-14) were recruited from Alpine communities in Canton Uri (Switzerland). Respiratory symptoms and information on potential confounders were collected by questionnaire in 1’246 children. Highway exposure was represented by either residential distance to the highway as a Gaussian function or dispersion model estimates of annual mean outdoor PM_{10}, $PM_{2.5}$ and NO_x concentrations from trucks and cars at home and school locations. Logistic regression models were used to assess respiratory health impacts. A subset of 13 children with asthma in Erstfeld (Canton Uri) also undergoes comprehensive respiratory and exposure assessment between November 2007 and June 2009. This includes measurements of inflammation and oxidative stress markers via exhaled NO and exhaled breath condensate, as well as monthly home outdoor and indoor measurements of NO_2 and $PM_{2.5}$. Concurrent measurements of continuous PM_1, particle number (PN), NO, NO_2 and NO_x are taken at a background and a highway site. The same pollutants are measured by a mobile station rotating around 7 locations in the community, 4 weeks at each location in each season. Daily PM_{10} filters, collected at mobile sites, are analyzed for 55 trace elements with XRF, for 1-nitropyrene with GC-MSMS, and for elemental (EC) and organic carbon (OC) with TOC. 14-day passive NO_2 are measured at different locations within the community. Using PM speciation we will estimate the source-apportioned outdoor exposure for each subject. Regression analysis will be used to examine longitudinal respiratory effects with source-apportioned outdoor exposure estimates.

Results

Questionnaire survey in children: When exposure was modeled as a Gaussian function of distance, a positive trend between exposure and wheezing, hay fever, several reported asthma attacks, as well as nose and eye problems were observed. Using the dispersion estimates (Figure 1), home outdoor PM_{10} from trucks was significantly associated with

Figure 1
Estimated odds ratios and confidence intervals of respiratory symptoms in children for the dispersion model estimates of PM_{10} (per interquartile range) from trucks and cars. *=p<0.05



wheezing in the chest (OR=1.24, 95%CI: 1.01-1.52) and hay fever (OR=1.26, 95%CI: 1.05-1.52). Significant associations were also found between PM_{10} from cars and wheezing (OR=1.30, 95% CI: 1.02-1.67). Similar results were observed for $PM_{2.5}$. NO_x concentrations, however, showed no associations with respiratory outcomes.

Asthma panel study: Figure 2 shows daily concentrations of EC and OC at mobile sites. The variation and levels of EC and OC concentrations are higher in winter than in summer. EC, as a traffic marker, shows a decreasing trend with increasing distance to the highway. Because concentrations at different locations in the community were measured in different weeks of a season, they were normalized by taking the ratio of these local measurements to those at the background site. PN is decreasing with increasing distance to the highway, while PM_1 is not (Figure 3A). There is a clear drop to background levels for NO_2 after ~100m distance to the highway (Figure 3B). The very low NO_2 ratios correspond to sites at higher elevations.

Figure 2

Daily concentrations of elemental carbon (EC) and organic carbon (OC) at mobile sites

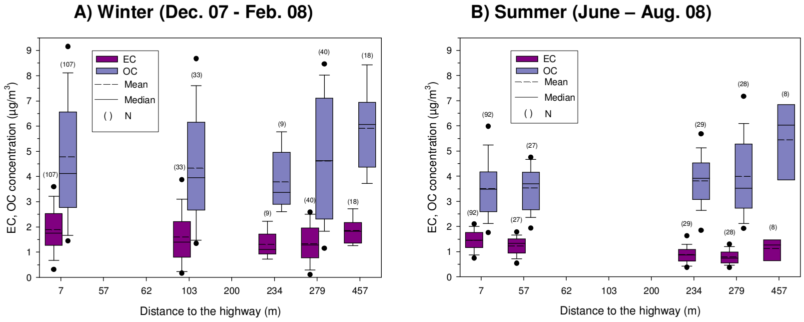
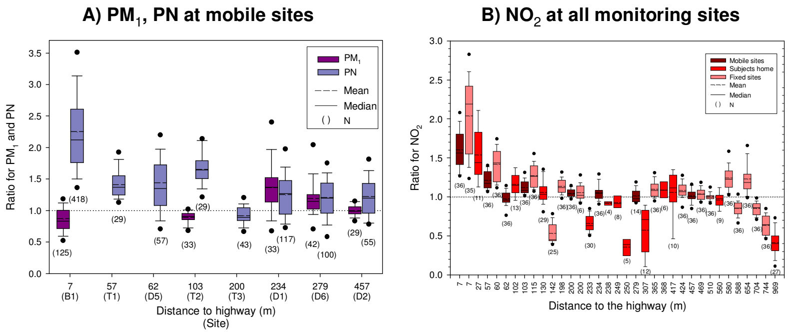


Figure 3

Ratios of daily concentrations at community sites to those at the background site. (Sept. 07 – Jan. 09)



Limitations

The dispersion model used for the questionnaire survey simplified the Alpine meteorology and topography and the model estimates have not been validated. As the questionnaire was self completed there might be a reporting bias. The questionnaire included little information on potential confounders and no information on time spent in/outdoors. Information of residence time was also missing.

Work in progress (asthma panel study)

PM_{10} in this highway community will be characterized with source apportionment. Dispersion model estimates will be validated with source apportioned estimates and source markers. Source apportioned data will be used in a land-use regression to model the outdoor exposure to highway traffic within the community for each subject taking time activity patterns into account. These estimates will then be used to assess changes in levels of exhaled breath NO and oxidative stress markers in exhaled breath condensate.

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INTRODUCTION

Although trans-Alpine highway traffic exhaust is the major source of air pollution along the highway valleys of the Alpine regions, no studies have examined health impacts from such exposure due to limited population and pollution measurements. This study aims to examine the impact of residential exposure to highway traffic on respiratory symptoms in children living in the Swiss Alpine highway corridor.

METHODS

1. **Cross-sectional questionnaire surveys** between 2005 and 2007 in 1840 adults (ages 15-70) living in 10 Alpine highway communities and in 1246 school children (age 6-14) living in Canton Uri.

Analysis method

- Logistic regression modeling including the distance to the highway and pollutant concentrations. Adjustments for sex, age, Swiss nationality, number of siblings, living on a currently run farm, parental smoking, maternal school graduation level, asthma in family, hay fever in family, neurodermitis in family , with random effect for community.
- Outcomes: Wheezing/whistling, nose and eyes problems, doctor diagnosed asthma, bronchitis, wheezy bronchitis, acute spasmodic laryngitis and hay fever.

METHODS (cont.)

2. **Asthma panel study** between November 2007 and June 2009 in a subset of 13 children in Erstfeld with monthly measurements of exhaled NO and oxidative stress markers in exhaled breath condensate as well as outdoor and indoor exposure measurements of NO_2 and PM components.

Air pollution monitoring

- Continuous PM_1, particle number (PN), NO, NO_2 and NO_x are measured by a mobile station rotating around 7 locations in the community, 4 weeks at each location in each season, and at a background and highway site over the whole study period.
- Daily PM_{10} filters are collected at mobile sites and analyzed for 55 trace elements with XRF, for 1-nitropyrene with GC-MSMS, and for EC/OC with TOC.
- 14-day NO_2 are measured at all sites.

Analysis method

- Estimates of source-apportioned outdoor exposure for individual subjects using PM speciation.
- Regression analysis of longitudinal respiratory effects with source-apportioned outdoor exposure.

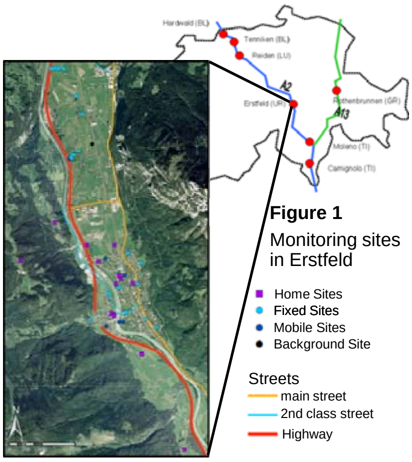


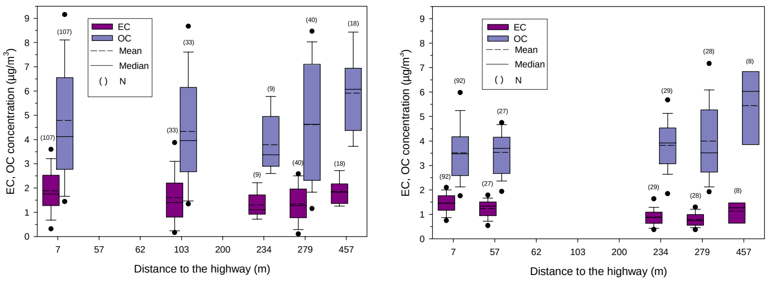
Figure 1
Monitoring sites in Erstfeld

RESULTS

ASTHMA PANEL STUDY

Figure 2

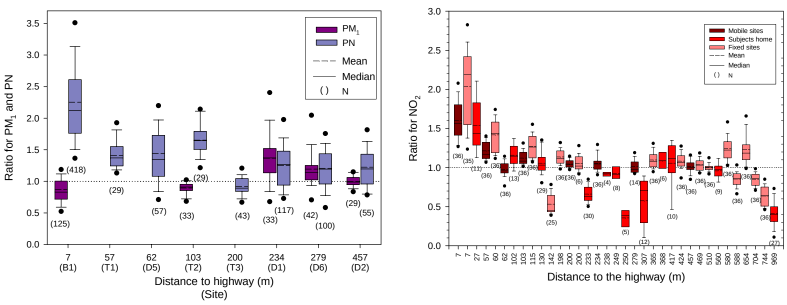
Daily concentrations of elemental carbon (EC) and organic carbon (OC) at mobile sites



EC and OC concentrations at mobile sites are slightly higher in winter than in summer. EC shows decreasing concentrations with increasing distance to the highway, especially in summer.

Figure 3

Ratios of daily concentrations at community sites to those at the background site. (Sept. 07 – Jan. 09)



Because concentrations at different locations in the community were measured in different weeks of a season, they were normalized by taking the ratio of these local measurements to those at the background site. With increasing distance to the highway a decrease can be observed for PN but not for PM_1 (Figure 3A). There is a clear drop to background levels for NO_2 after ~100m distance to the highway (Figure 3B).

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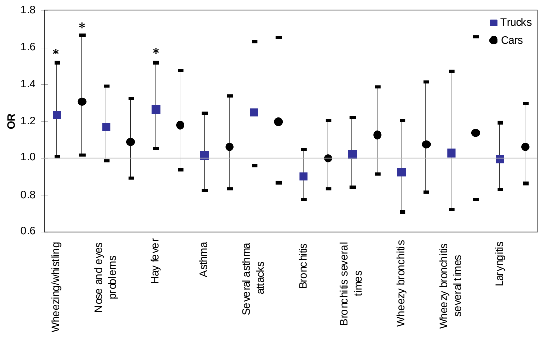
QUESTIONNAIRE SURVEY IN CHILDREN

Figure 4

Estimated odds ratios and confidence intervals of respiratory symptoms in children for the dispersion model estimates of PM_{10} (per interquartile range) from trucks and cars. *=p<0.05



Significant associations were found between symptoms and estimated PM_{10} from trucks (wheezing and hay fever) and cars (wheezing). We see more consistent results for several asthma attacks than for generally reported asthma.

LIMITATIONS / CURRENT WORK

Limitations (Questionnaire survey)

- The dispersion model simplified Alpine meteorology and topography. Model estimates have not been validated.

Health assessment

- Qualitative self assessment by subjects.
- There was only limited information of potential confounders and no information on time spent in/outdoor. We could not account for the duration of residence time.

Work in progress (Asthma panel study)

- Characterization of source apportioned PM_{10} in highway community.
- Validation of dispersion model estimates with source apportioned estimates and source markers.
- Land-use regression modeling of highway traffic exposure within the community.
- Modeling exposure to highway traffic exposure taking into account time activity patterns.

Health assessment

- Assessing levels of changes in upper airway inflammation marker, NO in exhaled breath, with levels of exposure to highway traffic.
- Assessing associations of levels of oxidative stress markers with exposure to highway traffic exhaust.