Impact of residential exposure to highway traffic exhaust on respiratory health of children in an Alpine valley in Switzerland

Regina Ducret - Stich1, 2, *, Harish Phuleria1, 2, Christian Schindler1, 2, and L.-J. Sally Liu1, 2, 3

1 Swiss Tropical and Public Health Institute, Basel; 2 University of Basel, Basel; 3 Department of Environmental and Occupational Health Sciences, University of Washington, Seattle, Washington, USA, *Contact: regina.ducret@unibas.ch

Background and Objective

Although trans-Alpine highway traffic exhaust is a major source of air pollution along the Alpine highway valleys, little is known about residential air pollution exposure and its impact on respiratory health. Previous questionnaire studies along the highway A2 found wheezing positively associated with proximity to the highway in adults (Hazenkamp-von Arx et al., 2011) and with traffic related PM10 (particulate matter <10 micrometer) in children (not published). The current pediatric asthma panel study is focusing on the short-term relationship between residential air pollution exposures and respiratory health outcomes and aims to study (1) residential outdoor exposure using spatial land-use regression (LUR) models, (2) contributions of different sources to PM10 (see source apportionment poster “Source apportionment of ambient PM10 near a major highway in a Swiss Alpine valley”) and (3) the relationship between spatially refined exposure estimates and respiratory health. This paper focuses on aim (3).

Methods

This work is part of an asthma panel study done in Erstfeld, Switzerland. This Alpine community is located in a narrow valley (about 1km wide) crossed by a major highway. From November 2007 to June 2009 13 children (ages 7–13) with asthma participated in monthly monitoring of respiratory health indicators including exhaled NO (eNO) as an upper airway inflammation marker and oxidative stress markers in exhaled breath condensate. Exhaled breath was collected in mylar balloons followed by NO analysis within 2-3 hours after collecting (Sievers Chemiluminescence NO Analyser). Exhaled breath condensate (eBC) was collected during tidal breathing for 10 minutes through an R-Tube covered by a cooling sleeve and stored (-80°C) until analysis for pH (micro electrode pH meter) and for Nitrite (eBC NO) (Griess reaction assay). At each visit records were taken about asthma symptoms, medication use, allergies, exposure to tobacco smoke, and a time-activity diary of the child for the day before the health monitoring.

Measurements of NO2 (nitrogen dioxide) at 13 locations in the community were used to model the home outdoor exposures with a land-use regression model (LUR). In addition different source contributions (e.g. diesel trucks, gasoline cars, biomass burning, etc.) to PM10 are quantified by source apportionment methods (see source apportionment poster “Source apportionment of ambient PM10 near a major highway in a Swiss Alpine valley”).
Statistical Analysis
Mixed models (random intercept) were used to assess the short-term impact of different pollutants (total PM$_{10}$ and EC at highway site, home outdoor NO$_2$ estimates from LUR-model, traffic PM$_{10}$ from source apportionment) with various lag times on the eNO levels. Covariates included asthma symptoms, medication use, allergies, presence of cold or flue, exposure to tobacco smoke, relative humidity, temperature, ambient NO, eBC PH, eBC NO, seasonal term, weekday term. They were selected on a significance level of 0.2. Two-pollutant models (incl. ozone) were also studied. All statistical analyses were performed with SAS 9.2 (SAS Institute Inc., Cary, NC).

Results
In the one-pollutant models only traffic PM$_{10}$ showed significant effects for the 2-day average (3.8%; CI: 0.04-7.64%) and the lag1-3 average (5.2%; CI: 0.5-10.1%). All other pollutants showed no significant effects. Inclusion of ozone only influenced EC and NO$_2$. For EC effects got significant for several lags after inclusion of ozone. We can see a trend of increasing effects in eNO from the general to the more specific air pollutant (total PM$_{10}$ to NO$_2$ to EC to traffic PM$_{10}$). Averages over several lag days seem to have a greater influence than single lag days.

Work in progress
- Estimation of diesel and gasoline contributions to PM$_{10}$ with Positive Matrix Factorization and validation using diesel markers.
- Association between biomarkers (eBC and eNO) and different air pollutants and sources will be investigated further.

References
Impact of residential exposure to highway traffic exhaust on respiratory health of children in an Alpine valley in Switzerland

Regina Ducret-Stich¹,², Harish Phuleria¹,², Christian Schindler¹,², and L.-J. Sally Liu¹,²,³
¹Swiss Tropical and Public Health Institute, Basel; ²University of Basel, Basel; ³Department of Environmental and Occupational Health Sciences, University of Washington, Seattle, Washington, USA

INTRODUCTION

Trans-Alpine highway traffic exhaust is a major source of air pollution along the Alpine highway valleys, but little is known about its impact on respiratory health. This pediatric asthma panel study aims to study:

1. residential outdoor exposure using spatial land-use regression (LUR) models
2. contribution of different sources to PM₁₀ (see source apportionment poster “Source apportionment of ambient PM₁₀ near a major highway in a Swiss Alpine valley”)
3. relationship between spatially refined exposure estimates and respiratory health.

METHODS

Health Monitoring

- Monthly monitoring of respiratory health indicators of 13 children (ages 7-13) with asthma from November 2007 to June 2009.
- Exhaled NO (eNO): Flow controlled collection of exhaled breath in mylar balloons (Figure 1a) followed by NO analysis within 2-3 hours after collecting with a Sievers Chemiluminescence NO Analyser
- Exhaled breath condensate (eBC): Collection during tidal breathing for 10 minutes through an R-Tube covered by a cooling sleeve (Figure 1b).
  - Analysis for pH with a micro electrode pH meter
  - Analysis for Nitrate (eBC NO) with Griess reaction assay
- Monthly questionnaires (for the 24 hours prior health measurements) about symptoms, health status, inhalator and medication use, exposure to smoking, home ventilation and a time activity diary.
- Baseline questionnaires about age, sex, socioeconomic status, birth history, health history, home characteristics, living environment and pets.
- Skin prick test for 22 allergens (different pollen, animals, molds, dust mites).

RESULTS

A. Summary of health measurements

Figure 3: Average values of eNO, eBC NO and pH for each child with indication of inhalator use

Children with regular inhalator use have in average lower eNO and eBC NO than children who are not using an inhalator (Figure 3). We also observed higher eNO for children with allergies to pollen or grass during allergy season.

B. Short-term effects of eNO

Figure 4: Percent increase in eNO per IQR of pollutant (two-pollutant models). Total PM₁₀ and EC were measured at the highway site, NO₂ was estimated with LUR-model and traffic PM₁₀ comes from preliminary source apportionment. IQR of traffic PM₁₀=1.6µg/m³, EC=0.9µg/m³, NO₂=0.9µg/m³, and total PM₁₀=15.8µg/m³. All models were adjusted for asthma status, inhalator use, presence of a cold or flu, current symptoms, health status, inhalator and medication use, exposure to smoking, home ventilation and a time activity diary.

In the one-pollutant models only traffic PM₁₀ showed significant effects for the 2-day average and the lag1-3 average. Significant effects for EC were only seen after inclusion of ozone. We can see a trend of increasing effects in eNO from the general to the more specific air pollutant. Averages over several lag days seem to have a greater influence than single lag days.

CONCLUSION & FUTURE WORK

- We found significant short-term effects between eNO and the traffic PM₁₀ and EC.
- Source apportionment is being refined to separate HDV diesel exhaust from gasoline cars using fractionated EC and OC.
- Association of biomarkers (eBC ad eNO) and different air pollutants and sources will be investigated further.