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Long-term personal exposure to traffic-related air pollution among school children, a validation study

Sofie Van Roosbroeck [a,*], Janine Wichmann [b], Nicole A.H. Janssen [c], Gerard Hoek [a], Joop H. van Wijnen [d], Erik Lebret [c], Bert Brunekreef [a,e]

[a] Institute for Risk Assessment Sciences, Utrecht University, P.O. Box 80176, 3508 TD Utrecht, The Netherlands
[b] School of Health Systems and Public Health, University of Pretoria, South Africa
[c] Center for Environmental Health Research, National Institute for Public Health and the Environment (RIVM), Bilthoven, The Netherlands
[d] Department of Environmental Medicine, Municipal Health Service Amsterdam (GG&GD), The Netherlands
[e] Julius Center for Health Sciences and Primary Care, University Medical Center Utrecht, The Netherlands

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Abstract

Several recent studies suggest an association between long-term exposure to traffic-related air pollution and health. Most studies use indicators of exposure such as outdoor air pollution or traffic density on the street of residence. Little information is available about the validity of these measurements as an estimate of long-term personal exposure to traffic-related air pollution. In this pilot study, we assessed outdoor and personal exposure to traffic-related air pollution in children living in homes on streets with different degree of traffic intensity.

The personal exposure of 14 children aged 9–12 years to 'soot', NO_x (NO and NO_2) was assessed in Amsterdam between March and June 2003. Each child's personal exposure was monitored during four repeated 48-h periods. Concurrently, in- and outdoor NO_x measurements were carried out at the school and at the home of each participating child. Measurements were supplemented by a questionnaire on time activity patterns and possible indoor sources. Flow-controlled battery operated pumps in a made-to-fit backpack were used to sample personal exposure to 'soot', determined from the reflectance of $PM_{2.5}$ filters. Exposure to NO_x was assessed using Ogawa passive samplers. Children living near busy roads were found to have a 35% higher personal exposure to 'soot' than children living at an urban background location, despite that all children attended the same school that was located away from busy roads. Smaller contrasts in personal exposure were found for NO (14%), NO_2 (15%) and NO_x (14%). This finding supports the use of 'living near a busy road' as a measure of exposure in epidemiological studies on the effects of traffic-related air pollution in children.

Keywords: Air pollution; Traffic; Personal exposure; Validation; Children; Soot; Nitrogenoxides

1. Introduction

Several recent studies show associations between air pollution and health (Brunekreef and Holgate, 2002). Results of three prospective cohort studies have suggested that long-term exposure to particulate matter

* Corresponding author. Tel.: +31 30 253 5400; fax: +31 30 253 9499.
E-mail address: s.a.h.vanroosbroeck@iras.uu.nl (S. Van Roosbroeck).

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(PM) air pollution is associated with increased mortality from respiratory and cardiovascular disease and lung cancer (Abbey et al., 1999; Dockery et al., 1993; Pope et al., 1995). These studies have compared several large study regions with different ambient air pollution concentrations, on the assumption that exposure was uniform within each region.

Due to recent reports of a significant variation of outdoor traffic-related air pollution within cities, a Dutch cohort study assessed exposure to air pollution on a smaller spatial scale by taking the proximity to major roads into account using a geographic information system (GIS) (Hoek et al., 2002a). Participants who lived closer to major roads had a significantly increased risk of death resulting from cardiorespiratory causes (Hoek et al., 2002a).

Several cross-sectional studies have also shown associations between traffic-related air pollution and adverse health effects (Delfino, 2002). These studies used indicators of exposure, such as traffic density on the street of residence, distance between the home and busy roads and/or estimated outdoor concentrations based on such characteristics. Little information, however, is available about the validity of these measurements as an estimate of long-term personal exposure to traffic-related air pollution.

The availability of validation data for short-term exposure studies is far more than that available for long-term monitoring. Several studies have documented that the temporal variation in outdoor particulate matter air pollution is reflected in temporal variation of personal exposure (Janssen et al., 1999, 2000). However, these studies do not provide information on the validity of outdoor air pollution concentrations for long-term exposure studies, which require spatial contrast in average outdoor air pollution.

A study conducted in the Netherlands at three schools near freeways with a range of traffic intensities from 45,000 to 150,000 cars/day showed significant differences in the long-term average personal nitrogen dioxide (NO_2) exposure of school children (Rijnders et al., 2001). Rijnders et al. found an estimated difference of 8.2 μg/m^3 (SE 1.8) between personal NO_2 exposure of the children attending the school with the highest and lowest traffic intensity; a difference of 46% (Rijnders et al., 2001). The increase in school outdoor NO_2 for these children was 41%, whereas the difference in home outdoor NO_2 concentration was 28% (Rijnders et al., 2001). A study by Monn also focused on long-term exposure and showed highly significant correlations ($R^2 > 0.9$) on a city-level between outdoor and personal annual mean estimates of exposure to NO_2 (Monn, 2001). However, no long-term studies have involved personal sampling of the probably more relevant particulate matter, with a 50% cut off of 2.5 μm in aerodynamic particle size ($PM_{2.5}$), and particulate components such as 'soot'. This lack of data hinders the interpretation of epidemiological studies on long-term air pollution exposures. In this pilot study we therefore aimed to evaluate the feasibility of personal monitoring for PM, since these procedures are known to be highly demanding for the participants. Since epidemiological studies on long-term effects of traffic-related air pollution identify children as a sensitive group, we selected school children as participants in this study. We assessed personal exposure to traffic-related air pollutants, $PM_{2.5}$, 'soot', and NO_x in locations with varying degrees of traffic intensity. The overall objective of this study was to test the validity of traffic-related characteristics as an estimate for the personal long-term exposure to traffic-related air pollution, including $PM_{2.5}$, 'soot' and NO_x.

2. Methods

2.1. Participant selection

We conducted a pilot study in an urban background school in Amsterdam. With the cooperation of the school board, 40 children from grades 7 and 8 (9 to 12 years of age) were asked to participate in the study. These children received an invitation with a cover letter explaining the purpose of the study. Candidates were asked to return a participation form and parents had to sign an informed consent form.

2.2. Study design

Personal exposure to traffic-related air pollution was monitored 4 times per child in March, April, May and June of 2003. Children carried a personal $PM_{2.5}$ sampler and an Ogawa passive sampler, to provide personal NO_x measurements, continuously for 48 h. Concurrently, home indoor and outdoor measurements of NO_x, and school indoor and outdoor NO_x, and $PM_{2.5}$ concentrations were collected using identical sampling equipment. Light absorbance was measured from all $PM_{2.5}$ filters as a proxy for 'soot' or elemental carbon. Absorption coefficients of $PM_{2.5}$ filters have been shown to be highly correlated with measurements of elemental carbon (EC) or 'soot' (Cyrys et al., 2003; N Janssen et al., 2001; NA Janssen et al., 2000; Kinney et al., 2000). Elemental carbon or 'soot' is a product of incomplete combustion and has been found to correlate with diesel exhaust