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Traffic-related differences in indoor and personal absorption coefficient measurements in Amsterdam, the Netherlands

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Abstract

Population studies indicate that study participants living near major roads are more prone to chronic respiratory symptoms, lung function decrements and hospital admissions for asthma. The majority of the studies used proxy measures, such as distance to major roads or traffic intensity in the surroundings of the home. Few studies have communicated findings of concurrently performed measurements of outdoor, indoor and personal air pollution in urban streets with high- and low-traffic density. Measuring light absorption or reflectance of particulate matter (PM) collected on filters is an alternative method to determine elemental carbon, a marker for particles produced by incomplete combustion, compared to expensive and destructive analytical methods. This study sets out to test the null hypothesis that there is no difference in personal and indoor filter absorption coefficients for participants living along busy and quiet roads in Amsterdam. In one study we measured personal and indoor absorption coefficients in a sample of adults (50–70 years) and, in another study, the indoor levels in a population of adults (50–70 years) and school children (10–12 years). In the first study, the ratios of personal and indoor absorption coefficients in homes along busy roads compared with homes on quiet streets were significantly higher by 29% for personal measurements ($n = 16$ days, $p < 0.001$), and by 19% for indoor measurements ($n = 20$, $p < 0.001$), while in the second study, the ratio for the indoor measurements was higher by 26% ($n = 25$ days, $p < 0.05$). Exposure differences between homes along busy compared to homes along quiet streets remained and significant after adjustment for potential indoor sources (such as cooking and use of unvented heating appliances). This study therefore provides tentative support for the use of the type of road as proxy measure for indoor and personal absorption coefficient measurements in epidemiological studies due to the limitations of the study.

Keywords: Personal; Indoor; Exposure; Traffic-related; Absorption coefficients

1. Introduction

Recent air pollution epidemiological studies conducted in Europe focus on the impact of traffic-related air pollution, or proxy measures thereof, on human health (Wjst et al., 1993;

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Edwards et al., 1994; Weiland et al., 1994; Oosterlee et al., 1996; Van Wijnen and Van der Zee, 1998; Hoek et al., 2002a). In these parts of the world, motorised traffic is the main source of outdoor air pollution generated in close proximity to people. Due to a lack of sufficient quantitative data on differences in concentration of traffic-related air pollutants, the majority of these studies used proxy measures, such as distance to major roads or traffic intensity in the surroundings of the home. Recently, these proxy measures have been applied in geographical information system (GIS) based models (Brauer et al., 2003; Hoek et al., 2002b). However, proxy variables for traffic-related air pollution exposure have to be validated directly for their use as exposure measures in epidemiological studies.

Only a handful of studies have communicated findings of concurrently performed measurements of air pollution in urban streets with high- and low-traffic density (Hewitt, 1991; Van Wijnen and Van der Zee, 1998; Janssen et al., 1997). Little contrast in outdoor PM_{10} (particulate matter (PM) with aerodynamic diameter less than 10 μm) concentrations was reported. Contrasts in outdoor absorption coefficient and black smoke ('soot') levels were more pronounced, however. Reflectance measurements of PM collected on filters are easily transformed into absorption coefficients according to standard equations. Filter reflectance is highly correlated with measurement of elemental carbon, a marker for particles produced by incomplete combustion (Janssen et al., 2001). One major source for these carbonaceous particles is diesel exhaust (Kerminen et al., 1997). Very few studies have reported on the influence of traffic intensity on concentrations inside homes (Fischer et al., 2000) or on personal absorption coefficient measurements. Evidence of an influence of traffic-related air pollution in the indoor environment would significantly reinforce the credibility of the reported health effects associated with motorised traffic (Wallace, 1996). Janssen et al. (2001) reported a high correlation between $PM_{2.5}$ (particulate matter with aerodynamic diameter less than 2.5 μm), filter reflectance and elemental carbon for daily outdoor ($R = 0.92$; $n = 47$) and indoor ($R = 0.85$; $n = 32$) measurements.

This study tests the null hypothesis that there is no difference in personal as well as indoor absorption coefficients measured on the same day for adults (50–70 years) and children (10–12 years) living along busy and quiet roads in Amsterdam. The study also seeks to examine what additional factors contribute to the variability other than the home location relative to traffic density.

2. Materials and methods

Indoor and personal air pollution exposure and questionnaire data collected by Janssen et al. (1998a) and Van der Zee et al. (1998) were used in the statistical analysis. The study conducted by Janssen et al. (1998a) is hereafter referred to as Study 1 and that of Van der Zee et al. (1998) as Study 2. Study 1 was conducted during 29 November 1993 to 30 March 1994. Studies 1 and 2 were conducted simultaneously during the next measurement period (17 October–22 December 1994). Both studies were conducted in Amsterdam, the Netherlands.

Study 1 investigated the validity of outdoor PM_{10} concentrations as a measure of exposure in time series studies and focused on the association between personal and outdoor 24-hour concentrations within participants over time. Seven to eight personal and indoor 24-hour home measurements per participant were collected, involving 50–70 year olds. In Study 1, 262 personal PM_{10} measurements were conducted on 37 participants living in 36 homes during 43 days. In total, 254 indoor PM_{10} measurements were conducted in 36 homes during 39 days. Air pollution measurements during Study 2 were performed in the framework of a multi-centre epidemiological study of Pollution Effects on Asthmatic Children in Europe (PEACE) and, therefore, did not exclude obvious indoor sources, other than environmental tobacco smoke (ETS). The study collected one or two indoor 24-hour measurements per home, involving adults (50–70 years) and school children (10–12 years). In Study 2, 246 indoor PM_{10} measurements were conducted in 134 homes during 42 days.

Different questionnaires were used in the two studies. In both studies indoor measurements were conducted using Harvard impactors (Lioy et al., 1988; Marple et al., 1987). Personal measurements during Study 1 were conducted using a personal impactor described by Buckley et al. (1991) (A.D.E Inc., Naples, Maine, USA). The average number of cars and trucks passing the high traffic homes in both Study 1 and Study 2 was 11,767 per day (range 5148–16,962 cars) and 550 per day (range 212–878 trucks), respectively (Amsterdam Municipal Health Services, 2004). The traffic counts for Studies 1 and