The Effects of Ultrafine Particles from Traffic Emissions on Children's Health (UPTECH): Study Design

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1 Introduction

The motivation of this study was the limited body of epidemiological data on the effects of ultrafine (UF) particles (<0.1 µm) on human health, particularly children. Therefore this project seeks to determine the effect of the exposure to airborne UF particles emitted from motor vehicles on the health of children in schools. To achieve this, firstly a comprehensive study design had to be developed, and some of its aspects validated, to encompass the immense complexity of this project. This paper presents the results of this work.

2 Materials/Methods

This cross-sectional study focuses on spatial variation in the exposure-health outcome relationship, among children aged 8 to 11 years. The main hypothesis which is being tested is that variations in long-term exposure to UF particles are associated with variations in specified respiratory, cardiovascular and inflammatory attributes. It is also hypothesised that this variation is independent of the effects of other factors, including other air pollutants, housing conditions, indoor exposure and socio-economic factors. The study targets the long-term rather than short-term health effects of exposure to UF particles and is being conducted in the Brisbane Metropolitan Area, in Queensland Australia.

Sample size was estimated to ensure that sufficient schools and individuals within schools are sampled to detect a change in health attributable to exposure, by comparing means (Spiegelhalter et al 2004) implemented in R (R Development Core Team, 2008), or more specifically detecting a linear trend accounting for moderate change in exposure (one standard deviation) (Hsieh et al. 1998) as implemented in PASS 2008 (Hintze 2008). The most extensive health measurement information is available from spirometry (FEV1) data. The sample size determination is based largely on these measurements along with typical values of significance (5%) and power (80%). Data on the range of exposure (3000 – 50000) and FEV1 intraclass correlation (approximately 0.01, G. Marks, personal communication, January 11, 2010) indicate that approximately 30 children at 25 schools, are required.

A random sample of all state schools in the Brisbane Metropolitan Area was selected and those that meet the selection criteria were considered eligible (classrooms used by 8-11 year olds are naturally ventilated, at least 250 children in the school, no major local air pollution sources, other than road traffic).

A questionnaire was also developed, to describe the study population, measure respiratory symptoms, illness and general health status, and measure potential confounders, including effect modifiers relevant to the analysis, such as housing conditions, socio-economic status, exposure to environmental tobacco smoke and ethnicity.

3 Results

All the details of the study design, which were assessed by the International Scientific Advisory Committee (ISAC) set up for this project, are available at: http://www.ilaqh.qut.edu.au/Misc/UPTECH_Study_Design_22Dec2010.pdf. The first three schools were tested during October to December 2010. Air quality data are collected continuously at 5 sampling locations (3 outdoor and 2 indoor sites) within the school grounds for two weeks at each school.

The outdoor sites (A, B and C) are selected across the school grounds in order to estimate the exposure profile with respect to the distance

from the nearest road. The outdoor site, B, is selected to represent, as best as possible, the overall exposure within the school grounds. Two classrooms (D and E), which are naturally ventilated and used by 8-11 years old children, are chosen as the indoor sites.

Particle number concentration is measured at all sites, while other particle and gaseous parameters are also measured at Site B, including particle size distribution in the submicrometer range (10 - 400 nm); particle surface area; elemental and organic carbon (EC/OC) components in particle emissions, in terms of $PM_{2.5}$, including the EC fractions (EC1, EC2, EC3) and the OC fractions (OC1, OC2, OC3, OC4 and Pyrolized Carbon); particle chemical composition (elemental composition, volatile organic compounds (VOC), Polycyclic aromatic hydrocarbons (PAH), aldehydes); particle mass (including PM_{10} and $PM_{2.5}$); NOx and CO; ions; culturable moulds; and meteorological conditions (wind speed and direction, relative humidity and temperature). Ozone data are available from EPA monitoring stations and indoor sites are also sampled for particle chemical composition (carbonyl compounds, VOC); CO_2; culturable moulds; endotoxins; and total bacteria. Classroom activities and characteristics are monitored in relation to moisture damages, cleanliness and other aerosol sources, with an activity diary and a questionnaire. Traffic characteristics, such as traffic flow rate and vehicle speciation, are also measured at each school.

Additionally, at least three school children, who consented to participate in the study, are asked to carry a personal particle number counter (Philips - NanoTracer), and a global positioning system all times, continuously for a total period of 24 hours. Each child and their parents or guardians are asked to record their travel and activities, during non-schooling and schooling hours, as well as any time when the sampler is not with the child throughout the 24 hour measurement period.

The following attributes, which are hypothesised to be related to spatial variation in UF particle pollution, were measured for the school children participating in the study: respiratory symptoms; lung function; airway inflammation; systemic inflammation; and endothelial function.

A database has been developed to manage the body of data collected in this project, including air quality and clinical measures. Analyses of the data collected at the 3 schools are being conducted. In the first instance, correlations between different air pollutants at the school are being investigated. This includes time series of the UF particle number concentrations at all the 5 sampling locations. These time series are the basis to determine the potential indoor or outdoor sources (Figure 1). High correlations between the measured data at indoor and outdoor locations imply that traffic emissions are the main source of UF particles in the classrooms. However, occasional incursions indicate the presence of indoor sources.

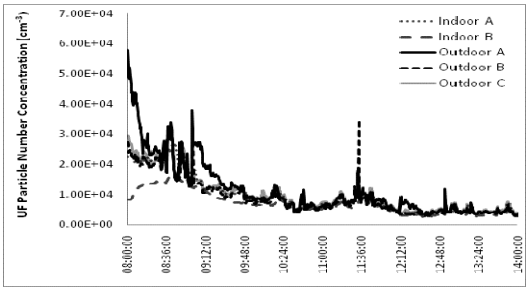

Figure 1. Indoor and outdoor UF particle concentrations at a school.

4 Conclusions

The measurement will be conducted at 22 schools in 2011 and 2012, to achieve the aimed 25 schools as per the sample size calculations for this project. Further analyses will be performed using the collected data at all the schools.

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6 References

Spiegelhalter, D. et al. (2004) Bayesian Approaches to Clinical Trials & Health-Care Evalutaion (in 'Statistics in Practice Series'). Chichester, UK, John Wiley & Sons Ltd.