Alveolar dose of ultrafine particles for children in urban environments

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Keywords: ultrafine particles, alveolar dose, children, urban environment.
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The aim of this study was to quantify school children's exposure to ultrafine particles (UFP) in urban environments. The study was conducted as part of a larger epidemiological project aiming to determine the association between exposures to UFPs and children's health, titled "Ultrafine Particles from Traffic Emissions and Children's Health"[1] (UPTECH). School children aged 8-11 years old at 24 state schools within the Brisbane Metropolitan Area participated in the present study. This paper presents the methodology and results for calculating deposited UFP surface area in the alveolar region (dose), where UFP deposition is more efficient for particles larger than 6 nm (ICRP 1994, Buonanno et al. 2012).

The alveolar surface area doses were derived using measured time-series of UFP number concentrations, $N(t)$, and average particle diameters, $d_{p,av}$, using Philips Aerasense Nano Tracers at 16 s sampling intervals. The doses were determined for the following activity microenvironments in a typical school day (recorded with an activity diary): school (in and outdoors), home (eating/cooking times, sleeping and other), other non-schooling activities (in and outdoors) and commuting.

The total dose for each activity within the 24 hour period of measurement for a child aged A, $\delta_{A,k}$, is calculated as

$$\delta_{A,k} = \sum_{j=1}^{J} \mathrm{IR}_{A,k} \int_{t_{1j}}^{t_{1j}} \int_{0}^{\infty} g\left(d_p, t\right) \, \mathrm{d}d_p \, \mathrm{d}t$$

where IR is the inhalation rate of activity k and $g(d_p,t)$ is the product of the estimated particle size distribution, the particle number concentration, per-particle surface area, πd_p^2, and the deposition ratio (Hinds 1999). The estimated particle size distribution is log-normal with mean $d_{p,av}(t)$ and standard deviation, σ_k, dependent on the activity (Buonanno et al. 2012).

Figure 1 shows the results of total dose and dose relative intensity (fraction of daily dose divided by fraction of daily time for that activity) calculations for the 39 children at the first 12 schools whose activity diaries comprise at least 23 hours of non-missing information. While most activities provide a similar contribution to the daily total dose, they do so with varying intensities and durations. The lowest median dose intensity is during sleeping, a time with very few sources of particles. The highest median dose intensity occurs during outdoor times at school, when particle number concentration (PNC) is moderately high and children are more active (higher breathing rate). The second highest dose intensity is commuting due to high PNC during commutes. Even though commuting dose intensity does not contribute highly to the total dose because of its short duration (3% of the day), it confirms the significance of exposure to traffic emissions .

[1]http://www.ilaqh.qut.edu.au/Misc/UPTECH%20Home.htm

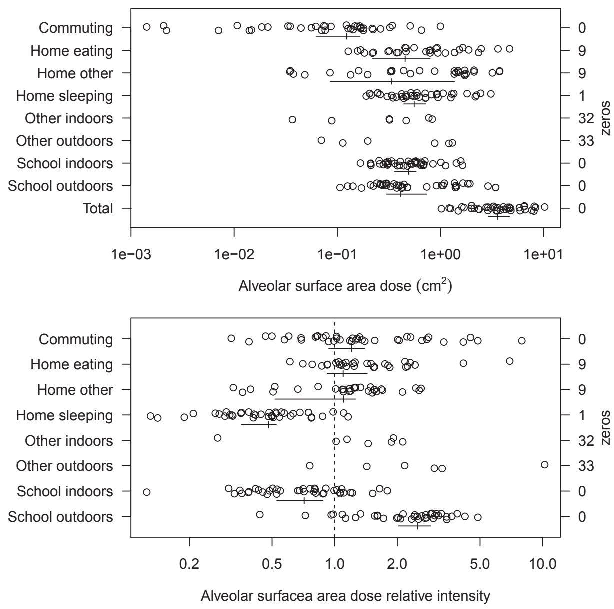

Figure 1: Calculated alveolar surface area dose and dose relative intensity with bootstrapped medians and their 95% CIs. Zeros account for the number of children whose activity diaries do not record any instances of that activity.

This work was supported by the Australian Research Council (ARC), QLD Department of Transport and Main Roads (DTMR) and QLD Department of Education and Training (DET) through a Linkage Grant LP0990134.

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