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Healthy commuting – exposure to particulate matter using different transport modes

Atmospheric particulate matter is one of the leading risk factors for premature death worldwide. Short-term exposure leads to worsening of respiratory symptoms, especially for patients with pulmonary diseases like asthma and COPD whereas long-term exposure increases the chance of developing lung cancer and cardiovascular disease, among others. Health problems are mainly associated with fine (diameter < 10 μm) and ultrafine (diameter < 100 nm) particles, because they are small enough to pass the upper respiratory tract and they can consecutively cause damage to lung tissue and even other organs.

Fig. 1. Map of chosen traffic routes. Subway runs underground for two thirds of the distance.

Particulate matter levels are usually high near traffic and the daily commute to work is responsible for a bulk of individual exposure. Several studies have tried to assess how choice of transport mode can impact personal exposure to particulate matter and shown conflicting results.

Methods
We selected a typical route a commuter would choose when going to work in the inner city and used different modes of transport (i.e. subway, bus, tram and bicycle) along the same route (Fig. 1) to find out if there are significant differences in exposure to fine (FPM) and ultrafine (UFP) particulate matter.

We compared mean exposure over time and also cumulative exposure over a fixed distance.

Results/Discussion
Fine particulate matter
Mean exposure to FPM was generally higher in the subway than in the bus or in the car (Fig. 2). This seems counterintuitive at first glance, since particulate matter levels are usually higher near sources like traffic. One explanation could be high air turnover in the subway due to open windows and large, frequently opening doors which leads to polluted air from tunnels and stations being transported into the cabin. Car and bus cabins, by contrast, are mostly ventilated with filtered ambient air, or even partly with recycled indoor air to conserve energy when air-conditioning is on. Air-conditioning is increasingly used in new subway trains in Vienna and one follow-up study has shown significantly lower exposure to particulate matter in air-conditioned trains.

Cumulative exposure to FPM along the same distance was lower in the subway when compared to the bus (Fig. 2), because the bus moves slower and therefore the commute is longer.

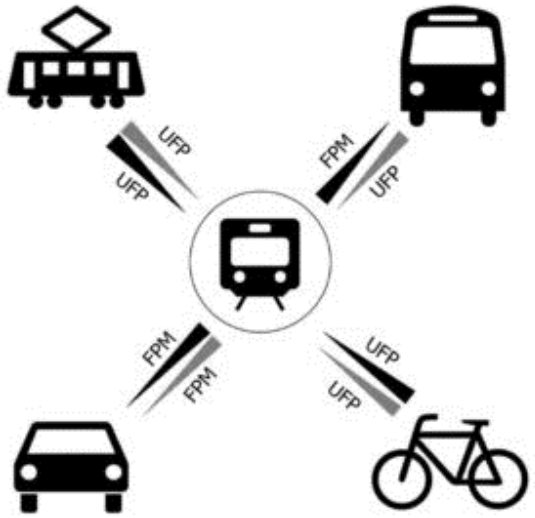

Fig. 2. Differences in exposure to ultrafine (UFP) and fine (FPM) particulate matter. Triangles broaden towards vehicles with higher exposure. Black triangles show mean exposure over time, grey triangles show cumulative exposure over fixed distance.

Ultrafine particulate matter
Mean exposure to UFP was higher in the tram and on the bicycle when compared to the subway (Fig. 2). This is not surprising, since the negative correlation between concentrations of ultrafine particles and distance to source (mainly motor traffic) is stronger with UFP than with FPM.

Studies have shown that bicycle riding is beneficial to health, even near traffic in urban environments, because benefits from physical activity offset negative health effects of air pollution.

Cumulative exposure to ultrafine particles was higher in the bus, when compared to the subway (Fig.2), mainly due to the slower speed of the bus.

There were no significant differences in exposure to either FPM or UFP between the above-ground vehicles.

The present study was the first one to explore for difference in personal exposure to particulate matter. Further studies including larger parts of the public transport system are needed to draw conclusions for any reliable recommendations.

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