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$PM_{2.5}$ and NO_2 exposure in different vehicle cabins with standard pollen and activated carbon filters

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Vehicle cabins are confined spaces where air quality can easily be reduced or improved by a combination of: ventilation settings, cabin air filter and route choice. By regulating the indoor-outdoor exchange rate using the vehicle's ventilation system or by opening and closing windows, occupants have the ability to self-control their exposure to both indoor and outdoor pollutants. Another important intervention to improve within-vehicle exposure to air pollution is to apply and regularly change the correct cabin air filters. Standard pollen cabin filters typically reduce small particles (i.e. fine particulate matter ($PM_{2.5}$)) from entering the vehicle's interior, effectively capturing pollen, dust, mould spores and debris, while activated carbon filters can additionally absorb some gases such as nitrogen dioxide (NO_2).

This study evaluated the impact of standard pollen and activated charcoal cabin filters on $PM_{2.5}$ and NO_2 exposure inside 10 vehicle cabins during real-world operation in Birmingham, UK. We examined five gasoline, two diesel, two hybrid and one electric vehicle on a consistent driving route on weekdays between 11:00-13:00, where $PM_{2.5}$ and NO_2 levels were measured simultaneously inside and outside of the cabin using two cross-calibrated optical particle sizer and chemiluminescent analysers respectively.

Using the appropriate ventilation settings in-cabin $PM_{2.5}$ were significantly ($p< 0.05$) reduced by up to 80±8.2% relative to the on-road levels. This reduction was similar for both standard pollen and activated carbon filters. No significant reductions of in-cabin NO_2 relative to the on-road NO_2 levels were found with the use of new standard pollen filters, with reductions ranging from 5.8±3.9 to 12.6±4.6%. Using new activated carbon filters, we found significant ($p< 0.05$) reductions of within-vehicle NO_2 concentrations relative to those measured on-road (reductions ranging from 86.1±4.7 to 94.3±3.2%). The reduction achieved remained significant when fresh air was coming into the cabin but under different fan power (medium, full) highlighting to importance of the new activated carbon filter in reducing within-vehicle NO_2 exposure. Three of the ten cars were also tested again after three months (or after 2,800-3,400 km) of the initial implementation of the new charcoal filter and the within-vehicle cabin NO_2 reductions remained almost equivalent to the initial performance (81.5±3.4 – 90.7±1.1%). In Europe 56% of the population use cars as their main transportation

mean on the daily basis, therefore, employing the appropriate cabin filter can significantly reduce $PM_{2.5}$ and NO_2 levels. These exposure reductions and the resulting health benefits may be greater amongst professional drivers.