Development of 1-hour exposure threshold concentrations for PM_{10} and $PM_{2.5}$

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The World Health Organisation (WHO), the European Union and US EPA have all published 24-hr exposure guideline values (GVs) for airborne particulate matter (PM). Nevertheless, epidemiological studies indicate human health effects, including inflammatory response, are evident after only a few hours for exposure to PM concentrations in the low hundreds of $\mu g\ m^{-3}$. This raises the question of whether GVs with shorter averaging periods should also be available, allowing public health guidance to be provided in a more timely manner to exposed populations. Such guidance would be especially important during episodic elevated PM concentrations that are prevalent during wildfires, industrial accidents and dust storms.

In this paper, we describe a novel method, based on Receiver Operating Characteristic (ROC) analysis, that allows the derivation of 1-hour threshold concentrations (TCs) for both PM_{10} and $PM_{2.5}$. The basis of the derivation is to select a 1-hour PM concentration-threshold that, if exceeded, predicts that the relevant 24-hour GV will also be exceeded, thus ensuring a link to epidemiological-evidenced guidelines. Our derivation is based on the ROC analysis of hourly PM data from over 38 million rolling 24-h periods for monitoring stations across the United States over the years 2014 to 2019. 1-hour TVs were derived for US Air Quality Index (AQI) 24-hour GVs of 'Unhealthy for sensitive groups', 'Unhealthy', 'Very unhealthy' and 'Hazardous', as well as for GVs from the WHO and UK. Exceedance of 1-hour TVs was found to be an excellent predictor of exceedance of the corresponding 24-hour GVs. As an example, for PM_{10}, setting the 1-hour TC at 561 $\mu g\ m^{-3}$ gives a 100% probability of predicting the exceedance of the US EPA 24-hour GV for 'Very Unhealthy' (set at 355 $\mu g\ m^{-3}$), whereas setting the 1-hour TC at 707 $\mu g\ m^{-3}$ gives a 99% probability of exceeding the same 24-hour GV. The advantage of using probability levels less than 100% is that the number of 'false alarms' is reduced.

Overall, the 1-hour TCs developed by our method should provide more responsive information on PM exposure, allowing quicker decisions to be made on the most appropriate public health response.