Effect of PM2.5 and regulatory thresholds on all-cause mortality among active commuters in two mega-cities

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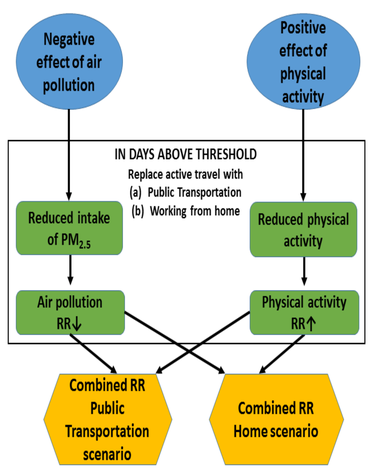
Background

Active commuting, such as cycling and walking to and from the workplace is associated with reduced all-cause mortality through increased physical activity (PA). However, cycling and walking, when performed in a polluted environment, result in increased respiratory uptake and deposition of harmful air pollutants such as fine particulates ($PM_{2.5}$), ozone and nitrogen dioxide in the lungs due to the increased ventilation during physical activity. Fine particulates ($PM_{2.5}$), in particular have been linked with increased cardiovascular, lung cancer and all-cause mortality. Consequently it is possible that active commuting, which translates to higher duration of exposure to outdoor air pollution in combination with a higher ventilation rate, will result in higher intake of $PM_{2.5}$, with potential increase in health risks. In this study, we assess the risk for all-cause mortality among active commuters who, in days with high $PM_{2.5}$ levels, either switch to commuting by public transportation or work from home.

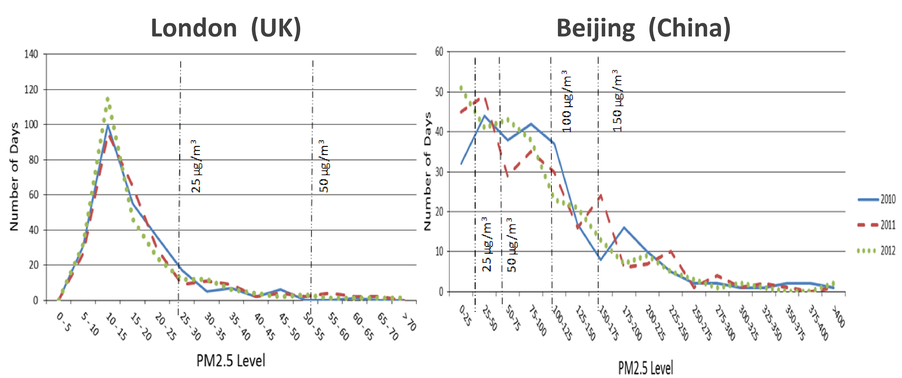
Methods

Day and night time $PM_{2.5}$ data were collected from two cities with different air pollution concentrations (London, UK and Beijing, China), for three consecutive years. A probabilistic model was developed to estimate PA benefits and air pollution risks while cycling and walking to work. In scenario days with more than 25, 50, 100 or 150 μg/m^3 daily $PM_{2.5}$ levels the active commuting was assumed to be replaced with public transportation or working from home. The model then estimated reduction in PA benefits and air pollution risks due to reduced active traveling in these days, averaged over the year.

To address the impact of each uncertain input to the total uncertainty of the output, as a sensitivity analysis, we performed importance analysis which calculates the absolute rank-order correlation between each input sample and the output sample. The model was developed in ANALYTICA Professional edition (Lumina Decision Systems, CA, United States)



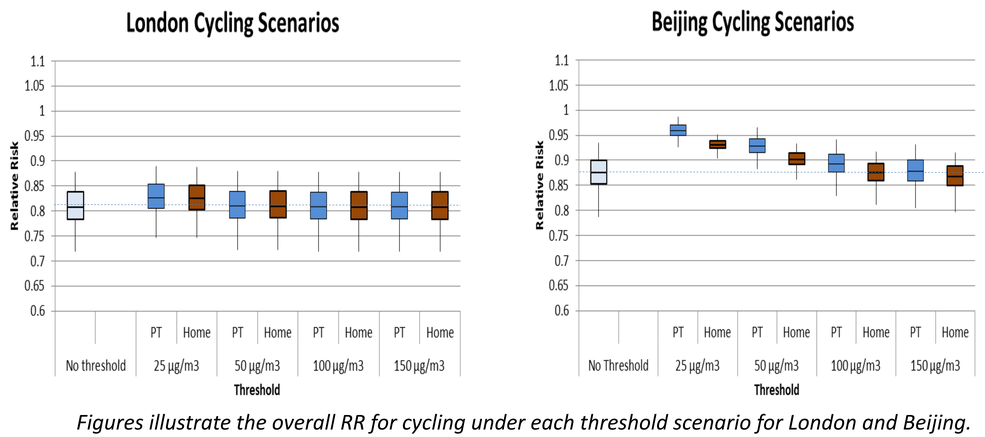
Overview of the Model design.



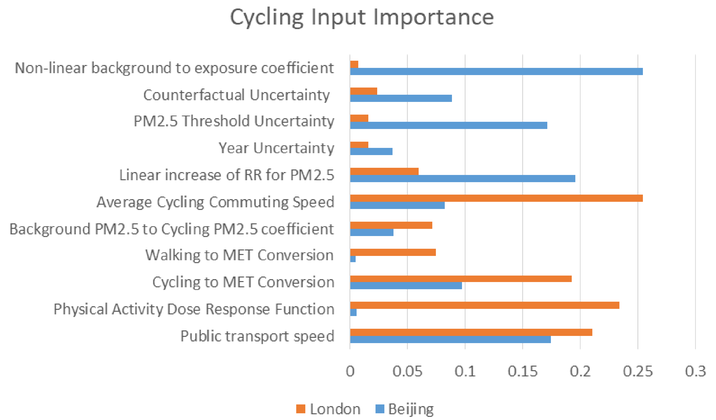
Figures illustrate the number of days with the corresponding $PM_{2.5}$ levels in London and Beijing. Vertical lines illustrate the fraction of days above the evaluated thresholds

Results

For London, the mean baseline Relative Risk (RR) for cycling to work was 0.81 (95%CI: 0.72-0.88) while the mean Baseline RR for walking to work was 0.86 (95%CI: 0.78-0.91). Instead for Beijing, the mean baseline RR for cycling to work was 0.88 (95%CI: 0.79-0.94) while the mean Baseline RR for walking to work was 0.90 (95%CI: 0.82-0.95). The effect of restricting active commuting in specific days on the relationship between cycling and RR for all cause mortality is presented below.



Figures illustrate the overall RR for cycling under each threshold scenario for London and Beijing.



Importance Analysis: Relative contribution of each uncertain parameter to the total uncertainty in the model estimates

Conclusions

In both cities, the mean RR for all-cause mortality for everyday active commuting was below 1, indicating a net protective effect. Switching to working from home in days with very high air pollution ($PM_{2.5}$>150 μg/m^3) could lead to slightly lower all-cause mortality risk in Beijing. Parameters identified to contribute significantly to the total uncertainty in the model results constitute primary targets for additional research.