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Assessment of air pollution exposures across a population: differences between home-based workers and bike commuters

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To improve our understanding of air pollution impacts on chronic diseases such as diabetes and cardiovascular disease it is essential to assess personal exposures to air pollution. To study the relation between air pollution exposure and chronic disease outcomes, long term (> 1 year) personal exposures are required for a large number of persons. However, in most studies, exposures are calculated as yearly averaged air pollution levels at fixed front door locations or averaged over buffer zones. These approaches ignore space-time activity patterns of individuals and therefore neglect the space-time variation of their personal exposure due to spatiotemporal variation in air pollution levels. One could observe space-time activity tracks of individuals using GPS devices and calculate exposure along these tracks. Though these methods provide detailed information about the trajectory of participants, they are not suitable for large-scale personal exposure assessment as the tracking data are often limited in size and duration.

To overcome this problem, we introduce a novel modelling approach that combines temporal land use regression modelling and agent-based modelling. Air pollution is estimated for each location in the entire residential area using temporal land use regression models available for each hour of the day, separately for weekdays and weekends, for each month of the year. Personal exposures to these modelled air pollution values are simulated using an agent-based model that is run for a complete year at an 1 h time step. We use pre-assumed activity schedules of individuals, with different activities during weekdays and weekends. The use of Monte Carlo simulation enables estimation of personal exposures for individuals over the entire residential area, including their uncertainties due to incomplete knowledge of the locations visited (e.g. work locations).

We apply this approach to the Dutch city of Utrecht (population 345,000) using temporal land use regression models for air pollution (NO_2, NO, PM10, O_3) set up using the Dutch National Air Quality Monitoring network. We analyze the air pollution exposure of people with two common mobility patterns: home-based workers staying at or close to their home and people commuting by bike. For both groups, personal exposures (for most pollutants) are highest for people living in the city centre or close to large roads. The variation in exposure among home-based workers is high, because they are either exposed, throughout the day, to either low or high air pollution depending on their living location. Cycling commuters are exposed to air pollution at multiple locations throughout the day and thus show a smaller range of yearly exposures, but overall somewhat higher than home-based workers because of high exposure levels during their commute trips.