Health effects of simultaneous exposure to physical & chemical properties of airborne particles

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Background

Airborne particles (PM) are a complex mix of organic and inorganic compounds, with a range of physical and chemical properties. Studies that have investigated the differential health effects of components of the airborne particle mix have generally used a single pollutant approach, looking at one pollutant at a time and treating other parts of the mixture as modifying or confounding factors. In reality our population is exposed to changing mixtures of airborne particles. Estimation of how simultaneous exposure to PM components affects the adverse health response is a challenge for scientific research and air quality management.

Method

Daily concentrations of particle mass concentration, chemical composition and particle number where measured at a central London background location from 2002 to 2005. Days with similar multi-pollutant and health response profiles where clustered, while adjusting for seasonal cycles, trends and temporal effects. This was carried out using a Dirichlet process mixture model with inference carried out via Markov Chain Monte Carlo methods. Pollution data from 2012 was also used to investigate if health changes had arisen from the combination of air quality management policies between 2005 and 2012.

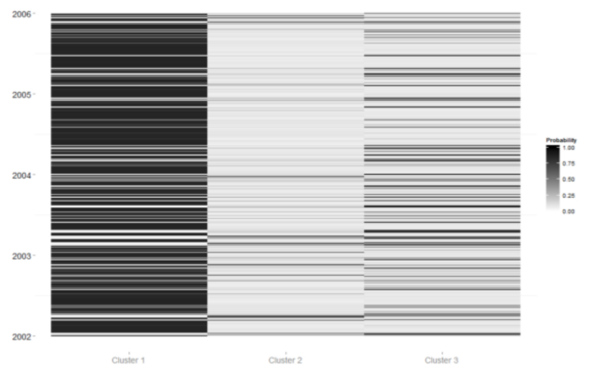

Figure 1. Probability that day *t* belongs to one of the 3 clusters. Cluster 3 (right) prevailed in spring and autumn.

Results

Days were partitioned into three clusters. A relative risk of 1.02 (95% CI: 1.00, 1.04) for respiratory mortality was associated with days with high non-primary PM, especially NO_3^- and SO_4^{-2}. These days were mainly in the spring and autumn (Figure 1). Using 2002 - 2004 as training set, the model performed well in the prediction of respiratory mortality in 2005 (Figure 2). Comparing 2012 with 2005 we found a reduction in PM, a change in the pollutant mixture and we predicted a decrease of 3.5% (95% CI: -0.12%, -5.74%) in average respiratory mortality in London.

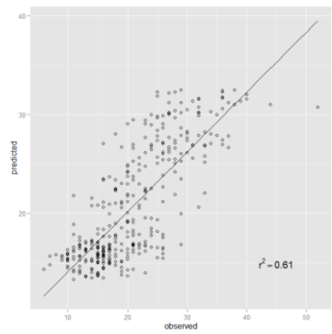

Figure 2 Observed and predicted daily mean mortality for 2005.

Conclusions

Our approach that enabled the better understanding of hidden structures in multi-pollutant health effects within time series analysis. It allowed the identification of exposure metrics associated with respiratory mortality and provided a tool to assess the changes in health effects from various policies to control the ambient particle matter mixtures. Rather than producing single-pollutant concentration response functions for use in health impact assessment or to assess the cost benefits of policies to decrease pollution exposures, our approach provides a predictive tool to allow the assessment of changes in the pollutant mixture. This is a far more realistic representation of the outcomes of the range of policies being employed across different emissions sectors at different spatial and government levels rather than taking a single pollutant approach.