Assessment of the effect of chronic exposure to outdoor air pollution in lung function using three-level hierarchical models

Venedictos Kapetanakis, Lindsay JL Forbes, Alicja R Rudnicka, David Strachan, Derek Cook, Peter Whincup, H Ross Anderson

Division of Community Health Sciences, St George's, University of London, United Kingdom

Abstract

Background: Many studies suggest that air pollution is associated with impaired health, including reduced lung function in adults. We aimed to estimate the association between average levels of exposure to outdoor air pollution and the forced expiratory volume in one second (FEV1) in both adults and children in geographically representative surveys in England.

Methods: We used data from the Health Survey for England (HSE) to examine the relationship between FEV1 and annual mean concentrations of outdoor air pollutants (particulate matter less than 10 microns in diameter (PM_{10}), nitrogen dioxide, sulphur dioxide and ozone) in years 1995, 1996, 1997, 2001 and 2002. Lung function tests were completed by trained nurses. Air pollution measurements were estimated from spatial models at $1km^2$ resolution as annual mean levels for each postcode sector of residence. Each of the five surveys was based on approximately 10,000 white adults aged 16 and older and 2,250 white children aged 2 to 15. We used multilevel regression modelling taking account of the hierarchical clustering of pollutant measures by postcode sector and the correlation between individuals living in the same household. Results from each year were then combined using meta-analysis. The heterogeneity between years was estimated using Chi^2 tests and the proportion of variability between studies attributed to heterogeneity rather than chance was estimated from I^2 values. All models took account of the association of lung function with age, sex and height.

Results: We found inverse associations between PM_{10}, nitrogen dioxide, sulphur dioxide and FEV1 in adults for the majority of the years. Our findings were consistent across all surveys (I^2= 25.6%, p= 0.26; I^2= 46.4%, p= 0.13; I^2= 0%, p= 0.58; for each pollutant respectively). The combined estimates suggested that an increase of 10μg m^{-3} in PM_{10}, nitrogen dioxide and sulphur dioxide concentration was associated with a decrease of 92 ml (95% CI: 55 ml to 130 ml), 22 ml (95% CI: 14 ml to 31 ml), and 22 ml (95% CI: 7 ml to 36 ml) in FEV1 in adults, respectively. On average, the variance of the random intercepts for the postcode sector and the household levels in the model with PM10 was 0.0114 lt^2 and 0.0338 lt^2 respectively. The variance of the residuals was on average 0.2383 lt^2. Similar variance components were found for nitrogen dioxide and sulphur dioxide. We found no associations between any of air pollutant measures and FEV1 in children. The corresponding variance estimates of the random intercepts for the postcode sector, the household levels and the residuals in the model with PM10 in children was 0.0069 lt^2, 0.0356 lt^2 and 0.0788 lt^2 respectively. For all the pollutants and across all the years, age, height and sex explained more than 80% of the total variability of FEV1 in childhood and approximately 71% in adult life.

Conclusions: The associations of PM_{10}, nitrogen dioxide and sulphur dioxide in adults were consistent with the effects reported in other epidemiological studies. The results provide evidence that air pollution may have an adverse effect in lung function in adults but no evidence for an association in children.