Health and economic benefits attributed to changes in air quality and traffic emissions induced by COVID-19 emergency measures in Oxford City, UK

Ajit Singh^1*, Suzanne. E. Bartington^2, Congbo Song^1, Omid Ghaffarpasand^1, Martin Kraftl^3, Tony Bush^4, Pedro Abreu^6, Zongbo Shi^1, Francis D. Pope^1, Brian Stacey^7, Stuart Cole^3, James Hall^2, G. Neil Thomas^2, William J. Bloss^1 and Felix C.P. Leach^4

^1 School of Geography, Earth and Environmental Sciences, University of Birmingham, Birmingham, UK
^2 Institute of Applied Health Research, University of Birmingham, Birmingham, UK
^3 Oxfordshire County Council, Oxford, UK
^4Department of Engineering Science, University of Oxford, Oxford, UK
^5 Apertum, Harwell, UK
^6 Oxford City Council, Oxford, UK
^7 Ricardo Energy & Environmen, Oxfordshire, UK
^8 Health Economics Unit, Institute of Applied Health Research, University of Birmingham, Birmingham, UK
^*Presenting author

Background. The COVID-19 pandemic has provided a unique natural experimental opportunity to assess impacts of human activity changes upon air quality, generating novel insights of relevance to public health. However, some existing studies examining changes in pollutant concentrations associated with COVID-19 'lockdown' measures have generated potentially misleading findings, typically relying upon before-and-after comparisons and failing to adequately account for the influences of weather, seasonal and long-term trends. Our analysis focuses on a detailed assessment of health and economic implications of air quality and traffic emissions changes arising from COVID-19 lockdown periods in Oxford, UK applying a machine-learning deweathering and detrending technique.

Methods. Machine learning techniques can be applied to quantify the contributions of emissions and meteorological factors to observed short-term changes in air quality during the lockdown periods. To quantify these changes, we apply a random forest (RF) algorithm-based weather normalization technique. This approach enables calculation of a 'deweathered' (weather-normalized) concentrations, reflecting air pollutant concentrations under average meteorological conditions, thereby quantifying the contribution of emissions changes during the study period.
We used traffic data obtained by motion detection sensor and applied emissions factors for the Oxford City fleet to characterise relative contributions of vehicle types to changes in NO_2 emissions during lockdown periods.
A health and economic impact estimation was performed to assess reductions in attributable mortality, life-years saved and associated economic benefits if the NO_2 exposure reduction from a lockdown scenario were to be maintained.

Results. Air quality improvements were most marked during the first lockdown with reductions in observed NO_2 concentrations of 38% (SD±24.0%) at roadside and 17% (SD±5.4%) at urban background locations. Observed changes in $PM_{2.5}$, PM_{10} and O_3 concentrations were not significant during either lockdown. Deweathering and detrending analyses revealed a 22% (SD±4.4%) reduction in roadside NO_2 and 2% (SD±7.1%) at urban background during the first lockdown, while no significant changes in the second lockdown. Deweathered-detrended $PM_{2.5}$ and O_3 concentration changes were not significant, while PM_{10} increased in the second lockdown only. Buses and passenger cars were the major contributors to NO2 emissions, with relative reductions of 56% and 77% respectively during the first lockdown, and less pronounced changes in the second lockdown. While car and bus NO2 emissions decreased during both lockdown periods, the overall contribution from buses increased relative to cars in the second lockdown. Sustained NO2 emissions reduction consistent with the first lockdown could prevent 48 lost life-years among the city population, with economic benefits of up to £2.5 million.

Conclusions. Our novel analysis indicates that reductions in criteria air pollutant emissions during lockdown periods are of lesser magnitude than those originally reported from observed air quality data. This work emphasises the need for rigorous evaluation of urban air quality interventions in the context of meteorological influences and long-term trends. A future emissions scenario consistent with traffic reduction in the first lockdown period would deliver some benefits for public health; however such changes would not reduce PM concentrations significantly and targeted emissions control policy measures will be more effective for substantive NO2 reduction. Further research focusing upon population health, economic and climate co-benefits arising from such interventions would be valuable to inform transport policy decisions in similar small and medium sized cities.