Institution: King's College London

Unit of Assessment: 2. Public Health, Health Services and Primary Care

Title of case study: ***Improving Air Quality and Health through Design and Evaluation of Traffic Control Schemes***

1. Summary of the impact

Poor air quality is an important public health issue especially in cities where traffic is the major source of pollution. It is estimated that 29,000 people die prematurely in the UK each year, and 310,000 in Europe, because of air pollution. King's research, based on the London Air Quality Network (LAQN), including emissions modelling and vehicle profiling, indicated that improvements in air quality could be achieved by restricting the entrance of specific vehicle classes into urban areas. These research outputs were utilised by the Mayor of London to introduce the Congestion Charging Scheme (CCS), from 2003 to the present, and the London Low Emission Zone (LEZ), from 2008 to the present. This research, together with King's ongoing evaluation of air quality and the impact of traffic control schemes in London, has created increasing international interest in this method of pollution control resulting in the adoption of similar interventions across Europe.

2. Underpinning research

King's scientists quantify the impacts of air pollutants on health

King's College London's Medical Research Council (MRC)-Public Health England (PHE) Centre for Environment and Health is a leading centre for research on air quality and health. The Centre is led by Professor Frank Kelly (King's 1992-date). In 1995, King's established the London Air Quality Network, which has evolved into the largest urban air quality network in Europe, consisting of over 120 fixed measurement sites for a range of pollutants including oxides of nitrogen (NO_x), notably nitrogen dioxide (NO_2), ozone (O_3) and particulate matter (PM). King's research used information from the LAQN to understand the sources of atmospheric pollution and to estimate the health impacts of these pollutants in a major urban environment. In cities, vehicles are the main contributors to air pollution; transport-related pollutants are strong oxidants which, when in contact with the delicate respiratory airways, lead to damage (Kelly, 2003). When these finding were linked to experimental chamber studies in human volunteers demonstrating decreased airway function and inflammation (Mudway and Kelly, 2004), this work contributed to the growing literature that identified exposure to transport-related pollutants as a cause of ill health.

King's scientists design and evaluate interventions to reduce harmful exposures

The King's team began research to inform the design and evaluation of traffic control schemes to improve air quality and hence health. Working in partnership with Transport for London, King's researchers utilised automatic number plate recognition (ANPR) data in combination with the King's urban dispersion model to predict the air quality impact of the introduction of a congestion charging scheme (CCS). A temporal-spatial design was employed in which modelled and measured air quality data from LAQN monitoring stations were used to compare time periods before (2001-2002) and after (2003-2004) the CCS was introduced. Using a range of approaches, King's researchers found evidence of only small changes in air quality from the CCS (Beevers and Carslaw, 2005). However, attributing changes to the introduction of the CCS alone is difficult because the scheme was introduced at a time when other traffic and emissions interventions were also being implemented (Kelly et al., 2011a). King's research suggested that the health benefits of the CCS introduction might be small (Tonne et al., 2008) and so began to determine the benefit of a London-wide low emission zone (LEZ). Prior to activation of the first phase of the LEZ in 2008, King's research showed that a LEZ could provide improvements in urban air quality, crucially predicting that the emissions controls enforced by the scheme were expected to have the greatest effect close to major roads with high volumes of heavy-goods-vehicle traffic. This research was instrumental in guiding the design of a carefully considered and extensive environmental impacts monitoring network, directed from King's, that generates robust air quality data from baseline to the present as part of our ongoing evaluation of the effectiveness of the LEZ (Kelly et al., 2011b).

3. References to the research

Beevers, S.D. and Carslaw, D.C. (2005). The impact of congestion charging on vehicle emissions in London. *Atmospheric Environment* **39**, 1-5. http://dx.doi.org/10.1016/j.atmosenv.2004.10.001

Kelly, F.J. (2003). Oxidative stress: its role in air pollution and adverse health effects. *Occup Envir Med* **60**, 612-616. doi:10.1136/oem.60.8.612

Kelly F, Anderson HR, Armstrong B, Atkinson R, Barratt B, Beevers S, Derwent D, Green D, Mudway I, Wilkinson P; HEI Health Review Committee. (2011a) The impact of the congestion charging scheme on air quality in London. Part 1. Emissions modeling and analysis of air pollution measurements. *Res Rep Health Eff Inst* **155**, 5-71. http://pubs.healtheffects.org/getfile.php?u=638

Kelly F, Armstrong B, Atkinson R, Anderson HR, Barratt B, Beevers S, Cook D, Green D, Derwent D, Mudway I, Wilkinson P.(2011b) The London low emission zone baseline study. *Res Rep Health Eff Inst*. **163**, 3-79. http://pubs.healtheffects.org/getfile.php?u=669

Mudway, I.S. and Kelly, F.J. (2004). An investigation of inhaled ozone dose and the magnitude of airway inflammation in health adults. *Am J Resp Crit Care Med* **169**, 1089-95. doi: 10.1164/rccm.200309-1325PP

Tonne C, Beevers S, Armstrong B, Kelly F J, Wilkinson P. (2008). Air pollution and mortality benefits of the London Congestion Charge: spatial and socioeconomic inequalities. *Occup Environ Med* **65**, 620-627. doi: 10.1136/oem.2007.036533

Research Grants

PI: Prof Frank Kelly with Prof Steven Belcher. Title: Clean Air for London (ClearfLo). Sponsor: NERC. Period: 2010 – 2012. Total Awarded: £2.8M.

PI: Prof Frank Kelly. Title: Traffic Pollution and Health in London. Sponsor: NERC. Period: 2011 – 2014. Total Awarded: £2.0M.

PI: Prof Frank Kelly. Oxidative Potential of Particulate Matter and Risk of Cardiovascular Disease: A Hybrid Toxico-Epidemiological Study. Sponsor: Department of Health Period: 2009-2010. £150K.

PI: Prof Frank Kelly. Title: London Congestion Charging Scheme: its impact on air quality & health. Sponsor: Health Effects Institute (US). Period: 2005-2007. Total Awarded: $700K.

PI: Prof Frank Kelly. Title: London Low Emission zone: its impact on air quality & health. Sponsor: Health Effects Institute (US). Period: 2006-2007. Total Awarded: $800K.

PI: Prof Frank Kelly. Title: London Low Emission. Transport for London. 2005-2007. £330K.

4. Details of the impact

Impacts of King's air quality research include: evidence linking poor air quality in urban environments to traffic; evidence to inform the policies to improve air quality; contributing to the design and implementation and evaluation of traffic control schemes in the UK; informing the development of schemes in other countries; evidence of measurable improvements in air quality; evidence of improvements in health outcomes. Beneficiaries from the research include the populations of urban centres that have benefited from control measures directed at traffic related air pollution.

King's research influences air quality strategy in London

In 2000, London's air quality was the worst in the UK and there was evidence to show that these pollution levels caused serious health impacts. Ken Livingstone, as Mayor of London published the '*The Mayor's Air Quality Strategy: Cleaning London's Air,*' in 2001 (updated in 2002) which drew heavily on information from King's London Air Quality Network (LAQN). The strategy put forward a

range of policies and proposals designed to move London toward the point where air pollution no longer poses a significant risk to human health. The underpinning research from King's, constituted an extensive programme that has delivered innovative modelling and monitoring methodologies, guiding the design of the Congestion Charging Scheme and subsequently the world's largest low emission zone (LEZ). London's LEZ was proposed in order to "accelerate the introduction of cleaner vehicles and reduce the numbers of older, more polluting vehicles" into the capital. King's researchers engaged in the LEZ feasibility study and, in 2005, King's was chosen to partner Transport for London (TfL) in delivering the London LEZ, which became a key component of The Mayor's Air Quality Strategy. In the assessment period, results from King's monitoring and modelling were used extensively by the Mayor's office. 'The Mayor's Air Quality Strategy' (2010) details current pollution levels and highlights measures which 'will result in significant reductions in pollution concentrations across Greater London.' King's LAQN is specifically identified for the contribution to monitoring of air quality and emissions. The LAQN index, developed by King's, is used throughout the report to 'provide a useful picture of the overall improvements in London's air quality'. The London Air Quality Network not only informs Transport for London, but can be used by the public to find, for instance, street-level, interactive current pollution maps; incidences of high pollution episodes; news, videos and podcasts pertaining to air quality; interactive graphs by London borough and yearly reports.

The LEZ was established in 2008 and has continued to the present. It operates 24 hours a day, 365 days a year. It applies to diesel-engine, heavy goods vehicles (HGVs), buses and coaches, larger vans and minibuses, using cameras to identify the registration numbers of vehicles and the Driver and Vehicle Licensing Agency (DVLA) database to identify a vehicle's emissions. The impact of the research undertaken by King's in partnership with TfL, not only encompasses the evaluation the effectiveness of the LEZ on an ongoing basis, but also ensured that key projected impacts of the scheme were understood and characterised well in advance of the implementation date, as part of the monitoring network design process. The 2008 TfL report 'London Low Emission Zone – Impacts Monitoring' details the collaboration with the King's LAQN saying that measurements provided by them "will be the first point of reference for stakeholders assessing the air quality impacts of the scheme and are the legal basis for assessing compliance with UK and European air quality objectives." This report also discusses the health impacts of the LEZ, utilising data that contributed to the Tonne et al, (2008) and Kelly et al, (2011b) research reports.

King's scientists provide expert advice and advocacy to UK policy-makers

Prof Frank Kelly from King's has actively advocated the merits of LEZs when giving expert advice to Environmental Audit Committee enquiries into air quality in the UK. Prof Kelly gave detailed verbal evidence to the House of Commons Environmental Audit Committee to aid in the compilation of their Air Quality Report. This report detailed the government's response to a previous meeting of the committee that found that "air quality was not seen as a priority across Government" and as such the UK was "failing to meet a range of domestic and European targets." Failure to meet standards could incur millions of pounds of fines. The single most important exposure to harmful air pollutants was known to be caused by transport. It was decided local authorities must be involved in tackling poor air quality. The government undertook this current enquiry to "assess the extent to which the Government had implemented the processes outlined in its response and to assess their results." Prof Kelly was one of the key people giving evidence and a reference was also made to LAQN documents when discussing how, in London, PM_{10} daily limit values were being exceeded. King's researchers have also compiled several reports for the Department for Environment Food and Rural Affairs (DEFRA). For instance, in 2009 they produced a report on 'Air pollution and emissions trends in London' that "summarises detailed and comprehensive assessment of trends in emissions and concentrations of NO_X and PM in London". They also produced a review of air quality modelling that "identifies specific policy needs for the use of models and evaluates each model in turn in terms of the scientific content and credibility of the models, their ease of use and transparency and their fitness for purpose in delivering DEFRA's needs. Many UK cities are now investigating LEZs with 15 local authorities being allocated central government funds to develop schemes similar to the London LEZ. King's researchers are members of the Committee on the Medical Effects of Air Pollutants, the expert advisory group of the Department of Health in the UK for which Kelly is Chair; Quantification of air pollution health

effects, a sub-group of COMEAP; and the Air Quality Expert Group, the DEFRA advisory group.

King's scientists provide expert advice to international agencies
Professor Kelly and colleagues played significant roles in the air quality review process initiated by the WHO in 2005, 2010 and again in 2012. Members of King's staff are also members of influential national and international scientific panels including: UN Economic Commission for Europe Convention on Long Range Transboundary Air Pollution; and the US Health Effects Institute investigation into the Health Effects of Traffic pollution.

King's research informs similar interventions throughout Europe
Since the inception of the LEZ, King's has contributed innovative analysis of pollution concentrations as part of our ongoing assessment of the impacts of the LEZ on air quality. This work has been of benefit to the UK, and other Governments around the globe, as they contemplate measures to reduce traffic pollution in increasingly congested urban areas. The LEZ was designed to move London closer to achieving national and EU air quality objectives. The use of traffic intervention schemes to achieve an improvement in air quality is now widespread. More than 200 cities in 13 European countries have introduced LEZ's and international teams are following King's lead in assessing their potential health benefit.

5. Sources to corroborate the impact

Mayor's Air Quality Strategy. London: Greater London Authority, 2010.
Main report: Clearing the Air. The Mayor's Air Quality Strategy.
Appendix C - Further Technical Information. How we model air quality in London:

London Air Quality Network.
Website Interactive pollution maps
Pollution episodes Interactive graphs

Transport for London (2008): London Low Emission Zone. Impacts Monitoring.
London Low Emission Zone. Impacts Monitoring Baseline Report, July 2008.
Appendix 5: Air quality monitoring networks.

House of Commons Environmental Audit Committee.
Air Quality Report. Ninth Report of Session 2010-12. (LAQN reference, page 9; Prof Kelly Oral Evidence from page 30): Evidence given by Professor Kelly 8th June 2011.

Department for Environment, Food and Rural Affairs
April 2009 report. Air pollution and emissions trends in London. Beevers S, Carslaw D et al.
April 2011 report: Review of air quality modelling in DEFRA

British Vehicle Rental and Leasing Association (BVRLA) LEZ implementation in England

World Health Organisation
WHO Air Quality Guidelines 2005 WHO Indoor Air Quality Guidelines 2010
US Health Effects Institute Traffic-Related Air Pollution: A Critical Review of the Literature on Emissions, Exposure, and Health Effects

Examples of international media coverage
China Radio International Portuguese media
Bloomberg TV Spanish media

Implementation of Low Emission Zones in Europe.
International teams following King's research into the benefit of LEZ's
Lisbon Low Emission Zone Australian Evaluation of London LEZ
Low Emission Zones in Europe