Assessing health effects of air quality actions: what's next?

Published Online November 14, 2018 http://dx.doi.org/10.1016/S2468-2667(18)30235-4

See Articles page e28

In *The Lancet Public Health*, Ian Mudway and colleagues[1] report an evaluation of the effect of the low emission zone (LEZ) in London, UK, on air quality and children's respiratory health. The LEZ was implemented in stages during 2008 and 2012, requiring vehicles entering Greater London to meet certain emissions standards or pay daily charges if they did not. The study team evaluated the health effect of the LEZ indirectly, by examining the association between air pollution exposure and respiratory health in school children living within the LEZ using a sequential cross-sectional study design over the period 2009–14. The study has many notable strengths, such as the well characterised study population, highly resolved exposure estimates based on home and school addresses, and high-quality respiratory health data, including lung function with and without bronchodilation. They documented small reductions in NO_2 and NO_x in central London during implementation of the LEZ, but the effect on children's respiratory health was less clear.

Interest in assessing the health effects of air quality interventions has grown in response to questions about the benefit of further tightening of air pollution regulations.[2] New research has strengthened the evidence for adverse health effects of air pollution at concentrations at and below current ambient air quality standards, supporting the case for further regulatory action.[3–5] Studies assessing the health effects of air quality actions are appealing since they are the closest epidemiological equivalent to controlled experimental studies, and thus might provide evidence for causal associations. This apparent advantage does not imply, however, that accountability studies are less susceptible to confounding that might bias results. We previously described the general challenges encountered in such studies.[2,6]

The study by Mudway and colleagues[1] shows some of the challenges in doing such research, and provides possible directions for future research. One common challenge is sufficient statistical power. The air quality effects of the LEZ in London were estimated to be small in an earlier analysis by the same study team,[7] reducing the statistical power for a direct evaluation of health effects. The analysis of air quality monitoring data in their current study during 2006–14 documented reductions of about 1 μg/m³ of NO_2 per year, with no change in measured particulate matter with a diameter of less than 10 μm (PM_{10}) and less than 2·5 μm ($PM_{2.5}$). The relevant exposure contrast deployed in the analyses were relatively small, in particular for PM_{10} and $PM_{2.5}$ (IQR <1 μg/m³). Statistical power issues are also apparent when looking at their main results, with some estimates significant only when combined over all 5 years. These limitations are likely to reflect a well known weakness of a cross-sectional design; a longitudinal design would have been preferred, as the authors note.

The detailed exposure assessment at 20 × 20 m grid point resolution for several pollutants (NO_2, NO_x, PM_{10}, and $PM_{2.5}$) is a notable strength of the study. A key feature was the use of novel modelling of exposures that allowed differentiation between effects of short-term and long-term exposures. Ideally, such analysis should be done in joint models, if correlations are not too high. Mudway and colleagues also pursued multipollutant modelling, but, given the high correlations among pollutants at each timepoint, they reported that those analyses were not informative. Advanced statistical methods are clearly needed to investigate the health effects of air pollution mixtures in future research.[8,9]

The absence of preintervention health data prevented the study team from a direct evaluation of the health effect of the LEZ. Prospective studies are potentially the most informative to overcome such obstacles, but usually require that investigators identify proposed actions in advance and begin work early enough to capture stable estimates of baseline conditions. This task is not easy, and opportunities to do such prospective research remain relatively scarce.

Another important aspect worth discussing is that the study[1] lacked a control population unaffected by the intervention, as acknowledged by the authors. Use of appropriate comparison populations unaffected by the intervention, simulation, and sensitivity analyses to evaluate choices of reference populations and of statistical models adjusting for background trends, remain important in future intervention studies.[2] In a Cochrane systematic review (unpublished) of interventions to reduce PM air pollution and their effects on health, studies without a control population were only used as so-called supporting evidence, highlighting the importance of such comparisons in intervention research.[10] New promising methods have been developed, including use of causal inference methods and counterfactual methods.[11,12] Such approaches would enhance the attribution of the changes in air quality and health directly to an intervention and should continue to be further explored.

Mudway and colleagues also place much emphasis on NO_2, in part because the annual exposure of many school children in the study remained above the EU NO_2 limit value of 40 μg/m³. The evidence for effects of NO_2, which in cities originates largely from vehicle exhaust and is considered a marker for traffic-related air pollution, has strengthened.[13] The Committee on the Medical Effects of Air Pollutants in the UK have released a comprehensive report to quantify the independent effects of NO_2 for health and burden assessments.[14] A key question that remains largely unresolved is whether NO_2 is a causal agent or only an indicator of traffic-related air pollution, given that correlations in space and time between concentrations of NO_2 and other traffic-related air pollutants are often high. The study by Mudway and colleagues adds to this quandary, and shows that more stringent measures to improve urban air quality and children's health might be needed.

*Hanna Boogaard, Annemoon M van Erp
Health Effects Institute, Boston, MA 02110–1817, USA
jboogaard@healtheffects.org

We declare no competing interests.

Copyright © 2018 The Authors. Published by Elsevier Ltd. This is an Open Access article under the CC BY-NC-ND 4.0 license.

1 Mudway IS, Dundas I, Wood HE, et al. Impact of London's low emission zone on air quality and children's respiratory health: a sequential annual cross-sectional study. *Lancet Public Health* 2018; published online Nov 14. http://dx.doi.org/10.1016/S2468-2667(18)30202-0.
2 Boogaard H, van Erp AM, Walker KD, Shaikh R. Accountability studies on air pollution and health: the HEI Experience. *Curr Environ Health Rep* 2017; **4:** 514–22.
3 Beelen R, Hoek G, Raaschou-Nielsen O, et al. Natural-cause mortality and long-term exposure to particle components: an analysis of 19 European cohorts within the multi-center escape project. *Environ Health Perspect* 2015; **123:** 525–33.
4 Di Q, Wang Y, Zanobetti A, et al. Air pollution and mortality in the Medicare population. *New Engl J Med* 2017; **376:** 2513–22.
5 Pinault LL, Weichenthal S, Crouse DL, et al. Associations between fine particulate matter and mortality in the 2001 Canadian Census Health and Environment Cohort. *Environ Res* 2017; **159:** 406–15.
6 van Erp AM, Cohen AJ. HEI's research program on the impact of actions to improve air quality: interim evaluation and future directions. Communication 14. Boston, MA: Health Effects Institute, 2009.
7 Kelly FJ, Armstrong B, Atkinson R, et al. The London low emission zone baseline study. Research report 163. Boston, MA: Health Effects Institute, 2011.
8 Dominici F, Peng RD, Barr CD, Bell ML. Protecting human health from air pollution: shifting from a single-pollutant to a multi-pollutant approach. *Epidemiology* 2010; **21:** 187–194.
9 Health Effects Institute. Development of statistical methods for multipollutant research. Research report 183, parts 1 and 2. Boston, MA: Health Effects Institute, 2015.
10 Burns J, Boogaard H, Turley R, et al. Interventions to reduce ambient particulate matter air pollution and their effect on health. *Cochrane Database Syst Rev* 2014; **1:** CD010919.
11 Zigler CM, Kim C, Choirat C, et al. Causal inference methods for estimating long-term health effects of air quality regulations. Research report 187. Boston, MA: Health Effects Institute, 2016.
12 Russell AG, Tolbert P, Henneman L, et al. Impacts of regulations on air quality and emergency department visits in the Atlanta Metropolitan Area, 1993–2013. Research report 195. Boston, MA: Health Effects Institute, 2018.
13 US EPA. Integrated Science Assessment (ISA) for oxides of nitrogen—health criteria (final report, 2016). EPA/600/R-15/068. Washington, DC: US Environmental Protection Agency, 2016.
14 COMEAP. Associations of long-term average concentrations of nitrogen dioxide with mortality. London: Public Health England, 2018.