HEI

STATEMENT

Synopsis of Research Report 163

HEALTH EFFECTS INSTITUTE

The London Low Emission Zone Baseline Study

BACKGROUND

The London Low Emission Zone (LEZ) baseline study, conducted by Professor Frank Kelly and colleagues, was funded under an HEI research program aimed at evaluating whether regulatory and other actions taken to improve air quality have resulted in the intended improvements in air quality, exposure, and health outcomes.

The London LEZ was designed to improve air quality in Greater London by restricting entry of the oldest and most polluting vehicles in phases. Beginning in February 2008, heavy-duty diesel-engine vehicles and then other classes of vehicles would have to meet Euro III emissions standards and, by 2012, the more stringent Euro IV standards. Low emission zones, also known as environmental zones, have been implemented in countries all over the world. With coverage of about 2644 km^2, the London LEZ is one of the largest and therefore provides an intriguing opportunity for research.

In planning their evaluation of the LEZ, Kelly and colleagues built upon their earlier investigation of the air quality impacts of London's Congestion Charging Scheme (CCS); they set out to study the potential impacts of the LEZ first on air quality and then on health using existing databases of electronic medical records from primary-care practices serving a majority of London residents. The HEI Research Committee funded the team to evaluate the feasibility of such a study by collecting baseline data before the LEZ went into effect and to develop methodologic approaches.

APPROACH

The investigators first conducted detailed emissions and air pollution modeling. Using an LEZ scenario in which heavy-duty diesel-engine trucks and buses were required to meet Euro IV emissions standards for particulate matter (PM) and nitrogen oxides (NO_x), they projected effects of the LEZ on the mix of vehicles entering the zone, their emissions, and air pollutant concentrations and compared them with those of a "base case" scenario, which assumed the LEZ had not been implemented. Specifically, they predicted total emissions and ambient concentrations of NO_x, nitrogen dioxide (NO_2), PM with an aerodynamic diameter ≤ 10 µm (PM_{10}) from exhaust, and PM_{10} from tire and brake wear throughout Greater London.

Using these projections, they evaluated the existing air monitoring network; as a result of this assessment, Transport for London, which is responsible for London's transport system, agreed to add or upgrade air pollution and traffic monitoring at seven key roadside locations. The final monitoring network available for study included 41 sites (28 roadside and 9 urban background sites within London and 2 roadside and 2 urban background sites outside London).

Using methods based on their earlier study of the London CCS, the investigators studied characteristics of PM that they hypothesized might explain its toxicity. They examined the oxidative potential and the metal content in extracts from archived filter samples of PM_{10} and $PM_{2.5}$ (PM with an aerodynamic diameter ≤ 2.5 µm) from the monitoring sites. Oxidative potential, an indicator of a compound's ability to cause damage via chemical reactions, was estimated using a cell-free in vitro assay (i.e., the synthetic respiratory tract lining fluid assay) developed by the team. The assay measured the ability of filter extracts to deplete the levels of three common antioxidant compounds (ascorbate, reduced glutathione, and urate) found in the lungs. They also analyzed each filter extract for a panel of metals previously associated with exhaust or with tire and brake wear and assessed their possible contribution to oxidative potential.

This Statement, prepared by the Health Effects Institute, summarizes a research project funded by HEI and conducted by Professor Frank Kelly of King's College London, United Kingdom, and colleagues. The complete report, *The London Low Emission Zone Baseline Study* (© 2011 Health Effects Institute), can be obtained from HEI or our Web site (see back page).

Kelly and colleagues assessed the feasibility of obtaining and using electronic medical records from London's primary-care practices to study possible health impacts of the LEZ. The records came from two sources: the Doctors' Independent Network and the Lambeth database, which together covered a total of 42 practices and about 300,000 patients. The investigators explored ways to classify practices according to predicted LEZ-related changes in pollutant concentrations while maintaining the confidentiality of patient data. Using NO_x as an index pollutant, they conducted exploratory cross-sectional analyses of the relationships between exposure and indicators of respiratory and cardiovascular diseases and looked at potential confounding factors, such as socioeconomic status, ethnic background, and smoking. They then estimated the statistical power of future epidemiologic studies to detect changes in health outcomes associated with expected LEZ-related improvements in air quality.

RESULTS

The modeling studies predicted modest reductions in total emissions of PM_{10}, NO_x, and NO_2 associated with the LEZ: PM_{10} emissions would decline by 2.6% in 2008 and by 6.6% by 2012, and NO_x would decline by 3.8% in 2008 and by 7.3% by 2012. The largest LEZ-related differences in NO_2 and PM_{10} concentrations were likely to occur along roadways; this finding was instrumental in guiding the design of the LEZ monitoring network.

The investigators reported that oxidative potential appeared to be greater in PM from roadside locations than in that from urban background locations. Oxidative potential was also greater in PM_{10} extracts than in $PM_{2.5}$ extracts, which the investigators suggested might indicate an important contribution from the coarse fraction of PM ($PM_{10–2.5}$). In PM_{10}, but not $PM_{2.5}$, the oxidative potential appeared to be associated with elevated concentrations of metals linked to mechanical wear on tires and brakes (e.g., barium, copper, molybdenum, and iron). In general, the experiments suggested that oxidative potential of PM_{10} was attributable more to the presence of metals than of organic compounds.

The investigators were successful in demonstrating that data from medical practices could be electronically linked to air pollution data at the postal code level. However, in some cases patterns of NO_x, NO_2, and PM_{10} concentrations were distinctive enough to permit identification of individual practices. Given potential concerns about patient confidentiality, they limited their analyses to NO_x.

The investigators' exploratory cross-sectional analyses largely found no statistically significant associations between baseline NO_x concentrations and selected indicators for respiratory and cardiovascular outcomes. The exception was a negative association in school-age children and young adults between NO_x and ever having had a diagnosis of asthma or obtained prescriptions for asthma drugs. This result could not be explained by smoking habits or socioeconomic status; chance or uncontrolled confounding remained possible explanations. Nonetheless, using their results, the authors estimated that a full-scale longitudinal study of the LEZ could have the power to detect a 5% decline in measures such as number of prescriptions for asthma drugs or consultations for respiratory infections in the part of the population experiencing the largest decreases in air pollution.

INTERPRETATION AND CONCLUSIONS

In its independent evaluation of the study, the Health Review Committee thought the investigators had taken a careful approach by building on methods first used in their study of the London CCS. A strength of the study was that the investigators identified and addressed gaps in the monitoring network before undertaking full-scale health studies. They showed that it was feasible to link potential LEZ-related changes in air quality to electronic health records from primary-care databases. However, some major providers of medical records were not convinced that patient confidentiality could be maintained and thus access to data for a large number of patients was not available; if unaddressed, the statistical power of future health studies could be limited.

The Committee thought the analyses of patterns in modeled air pollution concentrations and in the metal content and oxidative potential of archived PM filter samples were interesting and potentially useful for further research. However, it was concerned that, despite the large area affected by the LEZ, the predicted changes in PM_{10} and NO_2 concentrations were generally small and, as in the earlier CSS study, would be difficult to detect in actual monitoring data. The Committee thought the in vitro assay of oxidative potential was intriguing, but largely exploratory. Its usefulness for this study was limited because it primarily measured the oxidative potential of metals associated with tire and brake wear, not the tailpipe emissions targeted by the LEZ.

In summary, the LEZ baseline study was a creative effort to lay the groundwork for studying spatial and temporal changes in air pollutant concentrations and health outcomes in advance of a major regulatory intervention. It provides important lessons for future research into the health outcomes of actions to improve air quality.

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