HEI

STATEMENT

Synopsis of Research Report 216

HEALTH EFFECTS INSTITUTE

New Approaches to Air Pollution Exposure Assessment Using Mobile Monitoring

BACKGROUND

It is challenging to estimate exposures to outdoor air pollutants that vary highly over short distances and over short periods of time. Researchers are increasingly measuring air pollution using mobile monitoring by affixing monitoring devices to vehicles traveling systematically and repeatedly along road networks. Data collected this way can be used to produce maps of street-level exposure estimates. Questions remain, however, about the validity and use of these data in different locations and for different purposes. Dr. Joshua Apte and colleagues at the University of California, Berkeley, sought to improve mobile monitoring approaches and to test their suitability in a high-income country (United States) and a low- and middle-income country (India). Their study was funded through HEI's Request for Applications 16-1: Walter A. Rosenblith New Investigator Award.

APPROACH

Apte and colleagues considered the following overarching research questions: Does large-scale mobile monitoring produce useful results? What insights about traffic-related air pollution dynamics and patterns can be revealed by mobile monitoring? What are the potential limitations of mobile monitoring? The study builds on previous research by the investigators through which they collected a large amount of mobile monitoring data using Google Street View cars equipped with tools to measure several traffic-related pollutants, including black carbon, nitrogen oxides, and ultrafine particles.

First, they evaluated the extent to which observations from mobile monitoring collected during weekday work hours represented long-term observations of black carbon measured at fixed-site monitors in Oakland, California. For this analysis, they used two existing datasets, namely, over 300 hours of mobile measurements and data from about 100 fixed-site monitors that provided 100 days of continuous measurements to assess temporal and spatial variability.

Next, they explored and evaluated several approaches for mapping air quality in Oakland using those mobile monitoring data. Specifically, they compared an approach using repeated, full-coverage sampling (i.e., mobile monitoring on all roads, sampled many times) with alternative strategies that included using data from fewer roads or fewer sampling days, and supplementing the data with spatial prediction models. The investigators also evaluated the feasibility of mobile monitoring in a different setting by collecting over 400 hours of data over 19 months in the Malleshwaram neighborhood of Bangalore, India.

What This Study Adds

- This study evaluated the use of mobile monitoring for several air pollution mapping and exposure assessment applications.
- Apte and colleagues compared measurements collected through mobile monitoring with measurements collected at fixed-site locations and used the mobile monitoring data to develop maps of estimated potential exposure.
- They evaluated and compared such data and approaches in Oakland, California, and Bangalore, India.
- In both locations, they produced relatively reproducible maps of traffic-related air pollution with data from relatively few repeated drive passes.

KEY RESULTS

The investigators found that patterns of black carbon obtained using mobile monitoring in Oakland were very similar to the concentrations observed at the fixed monitoring sites. In addition, mobile measurements captured road-level variability and measurements along highways that were not available from the fixed-site monitors.

This Statement, prepared by the Health Effects Institute, summarizes a research project funded by HEI and conducted by Dr. Joshua S. Apte of the University of California, Berkeley, and his colleagues. The complete report, *Scalable Multipollutant Exposure Assessment Using Routine Mobile Monitoring Platforms*, ©2024 Health Effects Institute, can be downloaded from *www.healtheffects.org/publications*.

Next, Apte and colleagues produced maps of pollutant concentrations on sampled road segments using all available data (see Figure, left panel) and reduced datasets (middle and right panel). Visual inspection suggested that the various modeling approaches captured key features of the long-term concentrations of nitrogen oxide and black carbon. Maps developed using data from fewer roads or drive days resulted in negligible decreases in model predictions and performance even with substantial decreases in data requirements. The map produced with the full dataset, however, (i.e., many dozen drive passes on all roads, total drive time about 1,300 hours) contained localized pollution hotspots at intersections and locations with emissions sources that were not apparent in the other maps.

The campaign in Bangalore showed similarly that the highest concentrations were observed along highways, and the lowest concentrations were observed on smaller, residential streets. Concentrations of ultrafine particles were about four times higher, and those for black carbon about 100 times higher, in Bangalore than in Oakland. Despite differences in fleet composition, population density, and mean pollutant concentrations between the two locations, mobile monitoring produced relatively stable maps with data from about 10 drive days in both locations, with diminishing returns to precision with additional sampling beyond that.

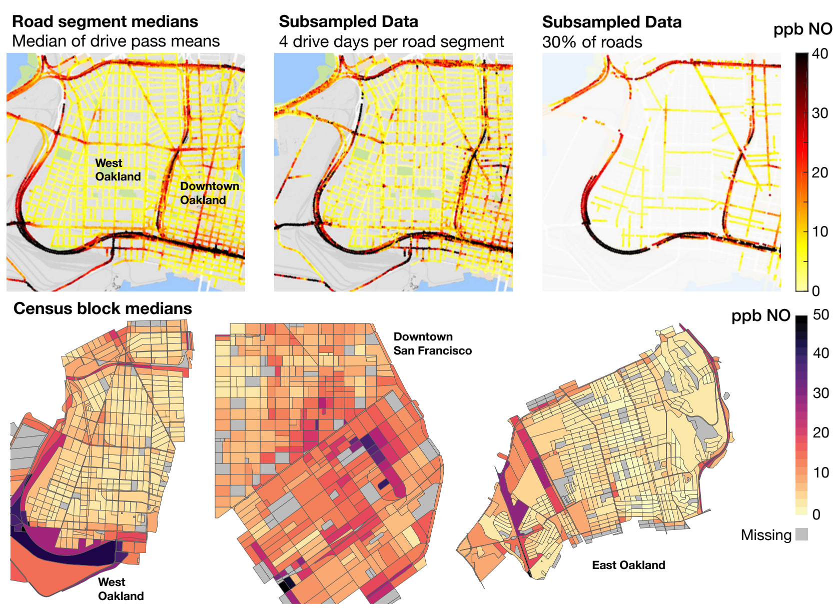
Results of this study also showed that some pollutants appear to be better suited for collection through mobile monitoring than others. Generally, pollutants with a high degree of spatial variation and a low degree of temporal variation were the best suited to this kind of approach.

Whether the results are generalizable to other pollutants or other locations (including to wider areas within California, Bangalore, or elsewhere) remains to be determined. The Committee also wondered about the suitability of mobile-measured air pollution data for use in epidemiological analyses or for regulatory purposes. For example, measurements collected in the middle of the road are likely different from those collected at roadsides or at other locations that might be closer to where people live. Additionally, the data used in this study were collected only during daytime hours on weekdays and do not reflect patterns during the times of day when people might be more likely to be at home (i.e., in the evenings, at night, and on weekends).

In summary, this study showed that mobile monitoring can be used to produce relatively reproducible maps of traffic-related air pollution with data from relatively few repeated drive passes, contributing interesting insights about collecting and working with mobile-measured air pollution data.

INTERPRETATION AND CONCLUSIONS

In its independent evaluation of the Investigators' Report, the HEI Review Committee commended the investigators for conducting one of the largest, most extensive studies examining the potential applications, strengths, and limitations of mobile monitoring. The rich datasets used by the investigators allowed them to explore and identify the relative trade-offs between intensive, repeated mobile monitoring and several alternative approaches. The study showed that mobile monitoring produced relatively reproducible maps for several traffic-related air pollutants with data from relatively few repeated drive passes, in two very different settings.



Statement Figure. Maps showing daytime median concentrations of nitrogen oxide in Oakland, CA, during 2015–2017, based on all available data (left), data from four randomly selected days (middle), and data from 30% of the arterial and residential roads (right). Source: Investigators' Report Figure 3.

HEALTH EFFECTS INSTITUTE

75 Federal Street, Suite 1400
Boston, MA 02110, USA
+1-617-488-2300 phone
+1-617-488-2335 fax
www.healtheffects.org