Air Pollution and Exposure Modelling

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Abstract

This presentation describes four different approaches to addressing methodological challenges in exposure assessment as part of the Border Air Quality Study (BAQS) funded by Health Canada. Four approaches are described including:

1. Developing a Spatial Exposure Simulation Model (SESM);
2. Modelling residential infiltration of ambient $PM_{2.5}$;
3. Modelling the spatial distribution of woodsmoke; and,
4. Evaluating the transferability of a land use regression model predicting NO2.

Background and Relevance

Studying human health and the environment is inherently spatial (Nuckols, Ward and Jarup 2004); however, most studies of air pollution and health use a limited number of fixed monitors to characterize exposure subjecting results to exposure misclassification which can obscure the relationship between air pollution and health. Improving estimates of exposure are critical for air pollution and health research, as well as for improving exposure assessment methods, a common limitation in health research.

Methods and Data

1. The SESM simulates working and non-working populations in each Census tract by randomly sampling from time-activity patterns and distributions of pollution levels in six microenvironments. The SESM requires a spatial surface of pollution, uses GIS to produce unique pollution distributions for each microenvironment in each census tract, and incorporates time-activity patterns from the Canadian Human Activity Pattern Survey, work flow data from Statistics Canada, and spatial property assessment data from local governments.
2. Paired nephelometers took $PM_{2.5}$ measurements at 40 homes to measure infiltration. Infiltration level was modeled using building characteristics documented in Spatial Property Assessment Data (SPAD) and meteorological data. A GIS model was developed to predict infiltration for individual residences in a large region.
3. Spatially representative measurements of fine particulate matter ($PM_{2.5}$) were collected the winter heating seasons of 2004/05, 2005/06, 2006/07 using a nephelometer installed in a passenger vehicle. Positional data were collected concurrently using GPS. Different methods for modeling woodsmoke were investigated: a baseline scenario, Kriging and regression modeling. The regression approach predicts concentrations of woodsmoke based on GIS variables available from census data, typically used in health research, and SPAD, an underutilized data source available at a finer spatial resolution.
4. Linear Regression was used to evaluate the fit of a source LUR model developed in Vancouver, BC, in nearby Victoria, BC, and Seattle, WA. Three scenarios were

explored: 1) Directly applying source model to the new cities; 2) Retaining the original variables, but allowing for local calibration of the model; and 3) Generating additional spatial variables and seeing if improved R^2 values could be achieved.

Results

1. For each population in each census tract, 10,000 calculations of exposure are performed by randomly sampling from distributions for each microenvironment**.**
2. The models developed from readily available spatial data hold promise for improving exposure assessment for indoor ambient $PM_{2.5}$ and therefore could reduce the error associated with current exposure predictions used in large epidemiology studies. In addition, this research identified a potential widespread source of environmental inequity. Lower income residences had significantly higher infiltration than other residences, which will lead to even higher exposure gradients between low and high socioeconomic individuals than previously identified through the use of only ambient pollution concentrations.
3. Using SPAD for predictor variables improved the spatial resolution and model performance over census data (R^2=0.33, p<0.00). Results of the woodsmoke model indicate areas experiencing above average concentrations of $PM_{2.5}$ not captured by the regulatory monitoring network.
4. When input data are available from the same source, a LUR may transfer to a geographically similar area reasonably well. Calibration using a small number of field samples can improve results, although careful consideration should be taken to place monitors in locations which capture the range of pollutants and land characteristics in the study area.

Conclusions

This presentation outlines some of the challenges and trends in spatial approaches to modeling exposure to air pollution. This research contributes to the field of exposure assessment by reducing the potential for exposure misclassification, cited as a major limitation in health research.

References

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