Research Report 236

Traffic-Related Air Pollution and Birth Weight: The Roles of Noise, Placental Function, Green Space, Physical Activity, and Socioeconomic Status (FRONTIER)

Payam Dadvand and Jordi Sunyer et al.

Additional Materials 3: Development of Hybrid Models for FRONTIER

Additional Materials 3 was reviewed by the HEI Review Committee. It has not been fully edited or formatted by HEI.

Correspondence may be addressed to Dr. Payam Dadvand, Barcelona Institute for Global Health (ISGlobal), Doctor Aiguader 88, 08003 Barcelona, Spain; email: *payam.dadvand@isglobal.org*.

Although this document was produced with partial funding by the United States Environmental Protection Agency under Assistance Award CR–83998101 to the Health Effects Institute, it has not been subjected to the Agency's peer and administrative review and may not necessarily reflect the views of the Agency; thus, no official endorsement by it should be inferred. It also has not been reviewed by private-party institutions, including those that support the Health Effects Institute, and may not reflect the views or policies of these parties; thus, no endorsement by them should be inferred.

Development of Hybrid Models for FRONTIER

1. Sampling Data

We developed our Hybrid models using data from two monitoring campaigns collected during the FRONTIER project.

A. **BiSC- Home campaign**: The first monitoring campaign was conducted between 2018-2021 at the home addresses of BiSC participants and involved measuring only NO_2 levels for one week during the first, and third trimester of pregnancy.

B. **BISCAPE campaign**: The second campaign was conducted in accordance with the ESCAPE guidelines, and included four distinct measurements periods: three in the winter, summer, and autumn of 2021., and a final one in the winter of 2022. During these periods, levels of NO2, PM2.5 and BC were measured at 34 locations across Barcelona Metropolitan Area.

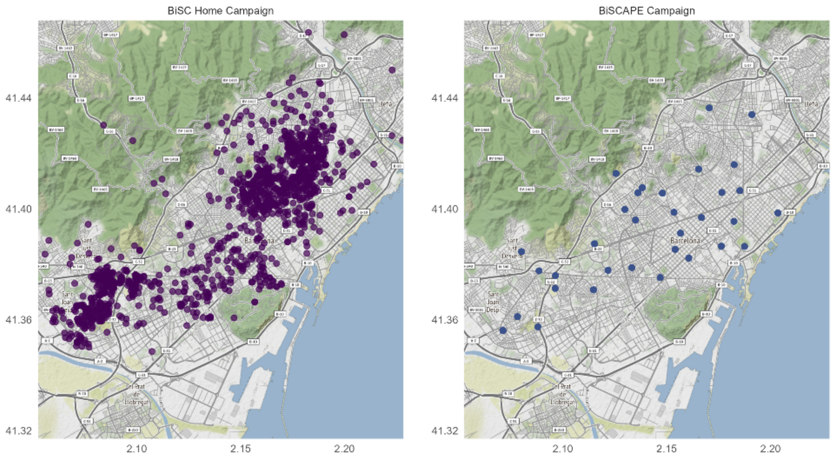

Figure S1. Study domain and spatial distribution of the monitoring campaigns. Right panel shows the BiSC home campaign and left panel show the BiSCAPE campaign.

2. Predictor variables

2.1. Spatial variables

To develop the hybrid models, we used the spatial variables created during the development of the LUR models. We selected spatial predictor variables from the same three categories than LUR (traffic, land use, and urban configuration) with different buffer sizes.

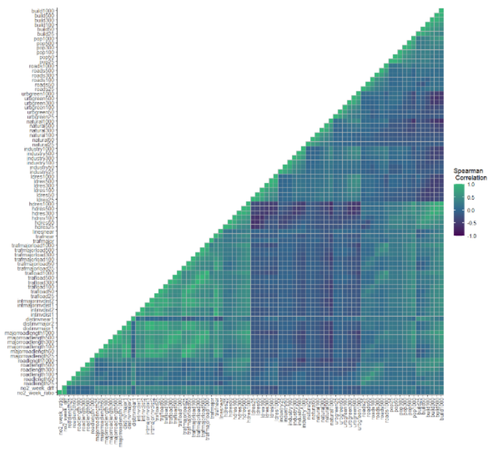

Figure S2. Correlation matrix between spatial predictor variables at different buffer sizes.

2.2. Air pollution monitoring stations (XVPCA stations).

We integrated additional data from the Catalan Air Pollution Monitoring and Forecasting Network (XVPCA) for Barcelona and surrounding areas. This data was interpolated using the Inverse Distance Weighting (IDW) method, which assigns higher importance to nearest stations. The data came from 16 monitoring stations, including Ciutadella, Eixample, Gracia, Hospìtalet, Ies Goya, Jardins, Obervatori Fabra, Palau Reial, Plaza Universitària, Poblenou, Sagnier, Sants, St. Adria, St. Coloma, Vall Hebron, Zona Unversitària. We calculate weekly average estimates for each week of pregnancy during the entire pregnancy from the IDW.

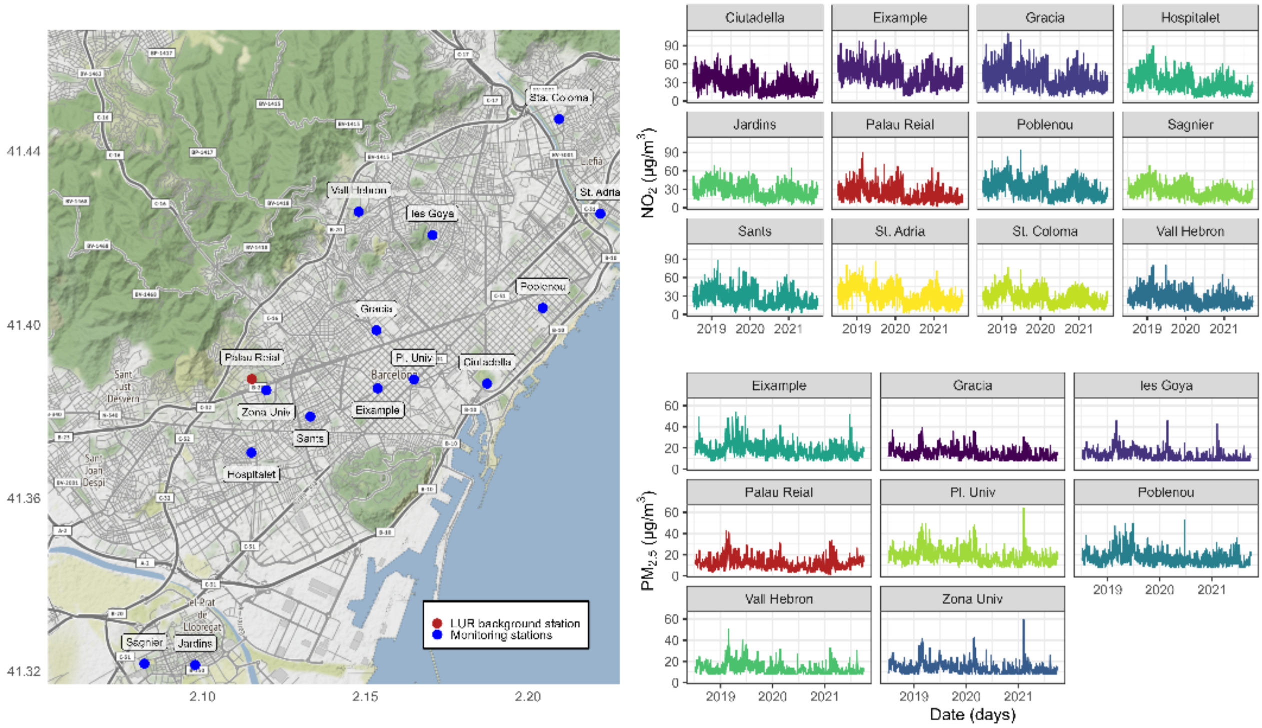

Figure S3. Monitoring stations from the XVPCA network used for Inverse Distance Weighting.

2.3. Traffic count measurements and meteorological data

While our dispersion model initially utilized meteorological and traffic data, the hybrid model broadened its scope by integrating daily traffic counts from 180 locations throughout the city. This broader data helps us better understand the spatial and time-specific variations in urban air pollution. To further refine our insights into the influence of weather patterns on air pollution, we sourced additional meteorological information, such as wind speed, and air temperature, from the Raval monitoring stations managed by Servei Meteorològic de Catalunya. We calculate weekly averages for each week of pregnancy during their entire pregnancy periods.

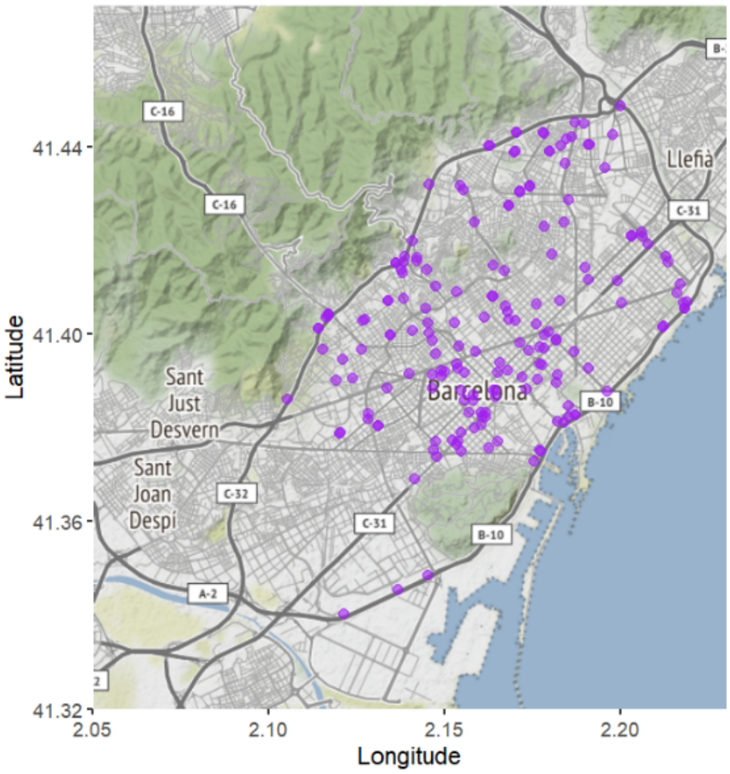

Figure S4. Traffic count measurements for the BiSC period (2018-2021).

2.4. Dispersion model estimates

Additionally, HM were largely based on daily concentrations from dispersion models, summarized as weekly averages. Weekly estimates were calculated for each week of pregnancy for all BiSC participants during their entire pregnancy periods and used as a predictor variable in the RF models. We used weekly estimates from the dispersion models for NO_2, $PM_{2.5}$ and BC, as inputs in the models. Additionally, road non-exhaust estimates from the dispersion models were used as inputs in the $PM_{2.5\text{-}Fe}$, $PM_{2.5\text{-}Cu}$, $PM_{2.5\text{-}Zn}$ models.

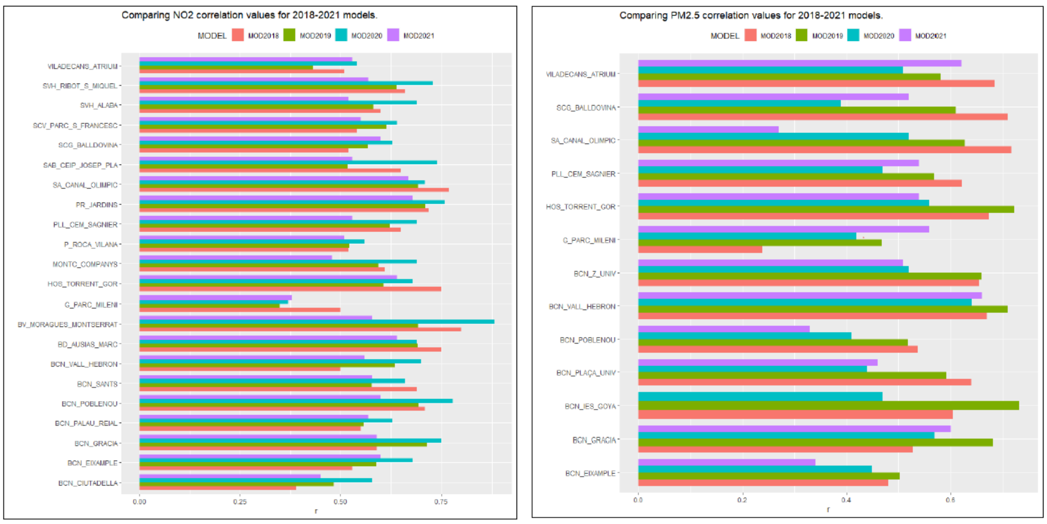

Figure S5. Correlation between the results of the model and the real observations of the XVPCA monitoring stations, for each year of analysis (2018 -2021).

3. Model development

Hybrid models were developed combining data from multiple sources as mentioned in the previous sections. With the aim to provide more accurate and reliable predictions we use the Random Forest algorithm. Briefly, RF models were fitted to each of the pollutant using all the available predictors available for the BiSC period. We employed the RF algorithm to capture non-linear relationships and potential interactions between predictor variables and the response variable, utilizing the *ranger* package in R implemented in the *caret* framework, a set of functions that attempt to streamline the process of creating predictive models.

3.1. Performance assessment

We assessed the performance of each hybrid models by contrasting predictions with observations using 10-fold CV and a external dataset. We follow a grid search for hyperparameter tuning to select the best configuration to obtain the optimal model based on the R^2. Additionally, we used an external validation set to check the performance on data that the model was not trained.

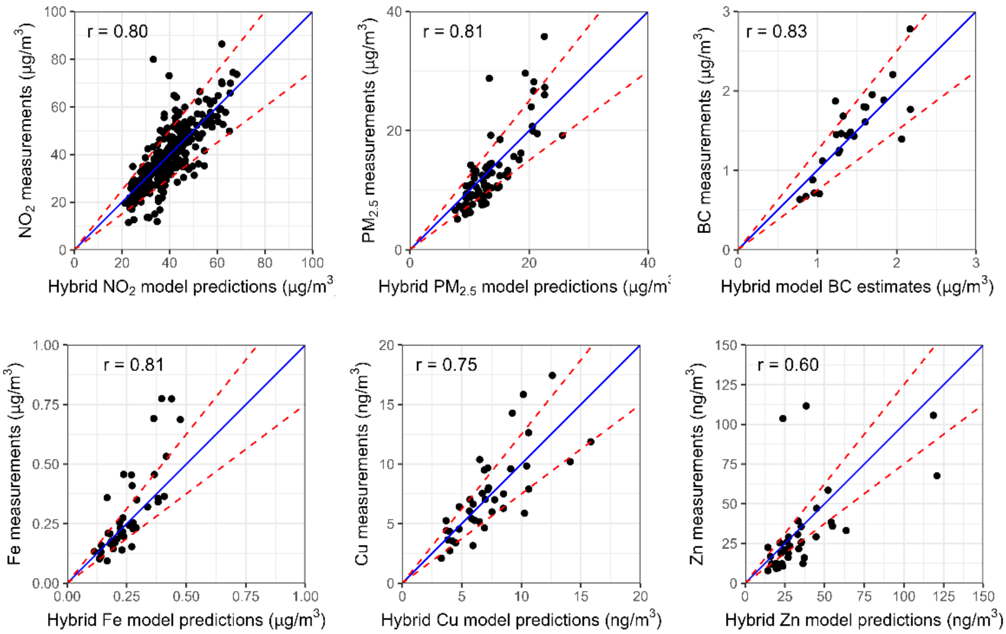

Figure S5. Comparison between measurements and predicted values for the hybrid models for NO_2, $PM_{2.5}$, BC, $PM_{2.5-Fe}$, $PM_{2.5-Cu}$, and $PM_{2.5-Zn}$ in the test dataset.

Finally, with the fitted models, we produced predictions for each week of pregnancy for all BiSC participants during their entire pregnancy periods.

3.2. Agreement between exposure assessment methods

We compared the weekly estimates predicted by each air pollution model. For NO_2, the models (LUR, DM and HM), exhibit similar patterns, though there is less agreement at higher value ranges. The $PM_{2.5}$ models demonstrate similar patterns to those found for NO_2 models, but with a lower density of predicted values at mean and higher levels. BC models show comparable patternts across the three evaluated models, yet there is less concordance when comparing DM and HM predictions specifically. For pollutants such as $PM_{2.5\text{-}Fe}$, $PM_{2.5\text{-}Cu}$, $PM_{2.5\text{-}Zn}$ we limited our comparison to HM and LUR models, as DM did not yield predictions for these pollutants. In the case of $PM_{2.5\text{-}Fe}$, $PM_{2.5\text{-}Cu}$, despite higher predicted exposure concentrations in the LUR models, the agreement was consistent for mean and lower predicted values. However, $PM_{2.5\text{-}Zn}$ exhibited poor agreement between the predicted values from both exposure assessment methods. This discrepancy may be due to variations in the performance of LUR and HM.

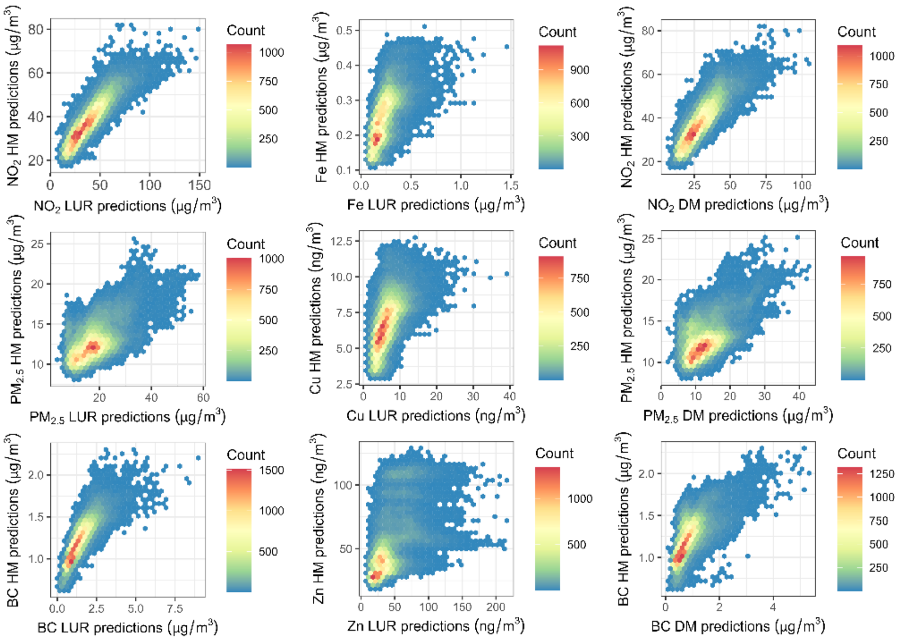

Figure S7. Comparison between weekly estimates for each exposure assessment method (LUR, DM, HM) for NO_2, $PM_{2.5}$, BC, $PM_{2.5-Fe}$, $PM_{2.5-Cu}$, and $PM_{2.5-Zn}$.