Assessing joint effects of blood lead and air pollution on children's 3rd grade standardized test scores in New York City birth cohort from 1994 to 1998.

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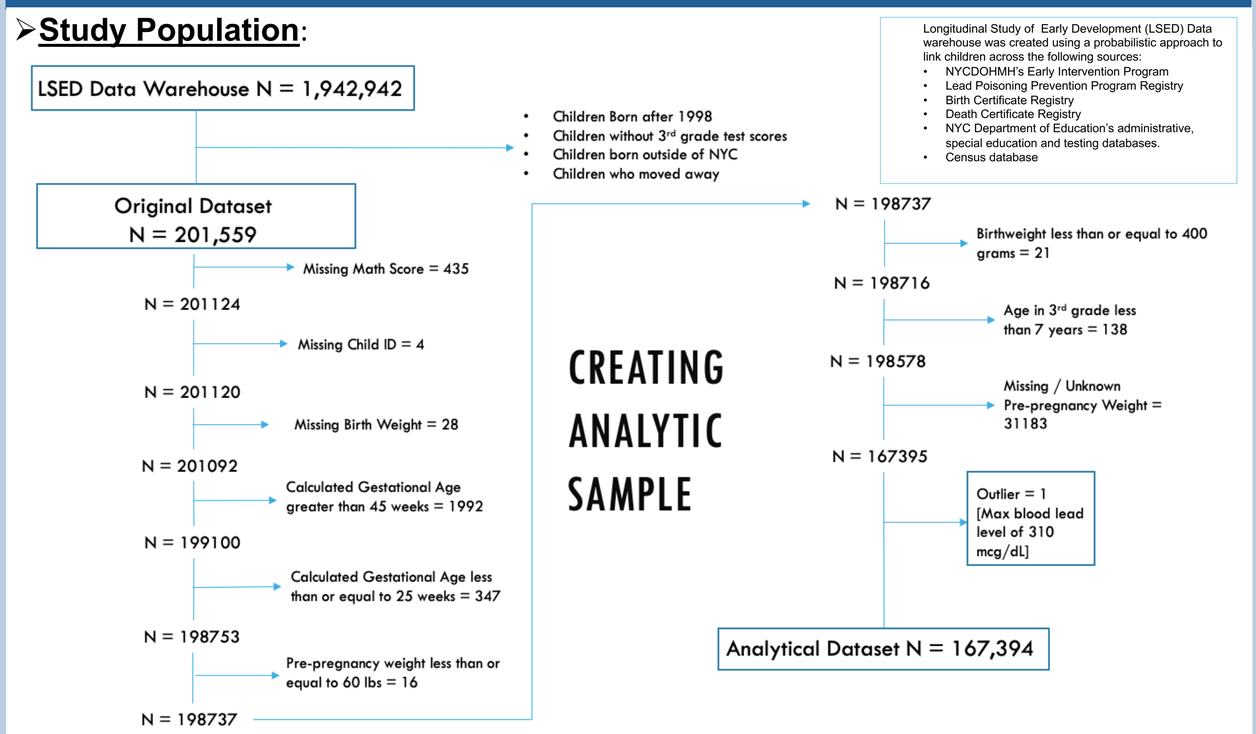
BACKGROUND

- Ambient air pollution and elevated blood lead levels have been individually associated with poor academic outcomes among children.[1,2]
- This study aims to examine the joint effects of blood lead and air pollution on children's 3rd grade standardized test scores.

METHODS

- **Study Population**:



- **Main Exposure**: Maximum Blood Lead Level
  - Scaled to increments of 5 since blood lead levels of 5 µcg/dL are considered higher than a normal or safe level for children.
  - A dichotomous variable was created: Less than 5 µcg/dL (n=104,049) and More than / Equal to 5 µcg/dL (n=63,345)
  - Blood lead measurements were missing for 21.6% of the population, 5 multiple imputations were carried out by predictive mean matching method using MICE package in R.

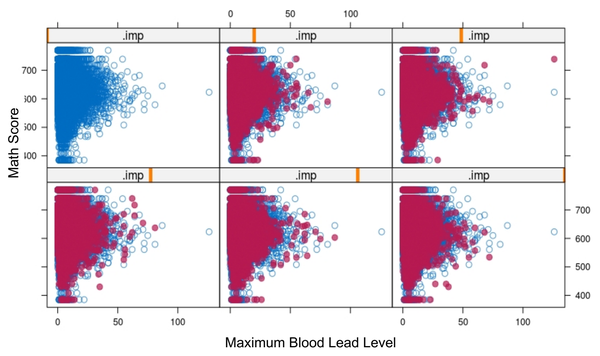
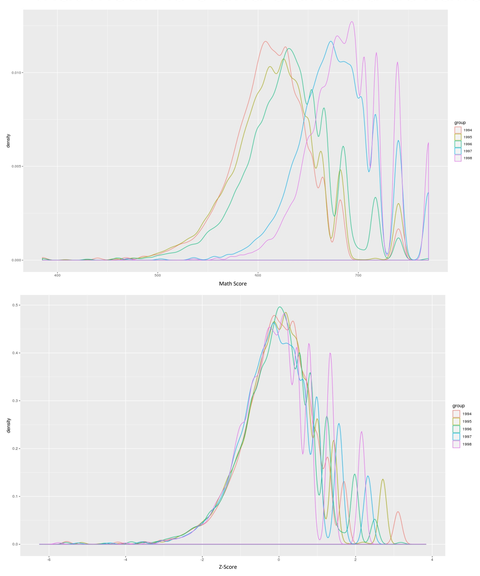


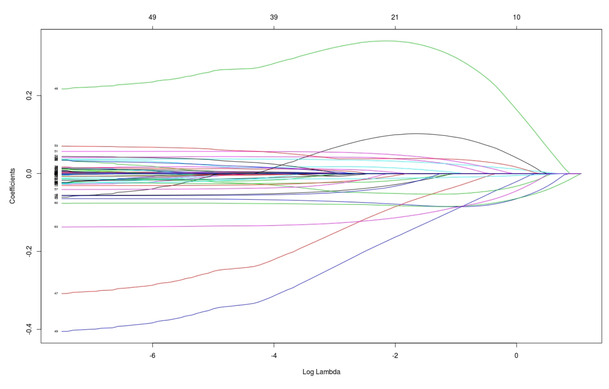
Figure 1: Scatter plot visualizing math score versus maximum blood lead level and distribution of imputed blood lead values across 5 imputations

- **Outcome**: Standardized Math Score (Z-score)
  - Math score was grouped by birthyear of the child
  - Each score was assigned a Z-score such that mean is 0 and standard deviation is 1.



- **Confounding variables**: Following confounders were identified through review of previous literature and DAG analysis:
  - Maternal race/ethnicity
  - Maternal nativity
  - Maternal educational attainment
  - Maternal age at delivery
  - Maternal marital status
  - Maternal employment status during pregnancy
  - Maternal pre-pregnancy weight
  - Maternal pre-existing risk factors
  - Tobacco use
  - Alcohol use
  - NYCHA housing
  - Days absent in 3rd grade
  - Lunch eligibility in school
  - Neighborhood deprivation index.
- **Statistical Analysis**: Linear regression models were constructed and analyses were repeated after stratification by sex of the child.
- **Feature Selection**: Feature selection was performed using elastic net regularization. The results were consistent across each imputed dataset and 9 out of 40 air pollutants were identified using this method to be used in the final model:
  - Vinyl Chloride
  - Polychlorinated Bisphenols (PCB)
  - Hexachlorobenzene
  - Perchloroethylene
  - Lead
  - Chromium
  - Polycyclic Organic Matter (POM)
  - Methyl tertiary butyl ether
  - Polycyclic Aromatic Hydrocarbons (PAHs)

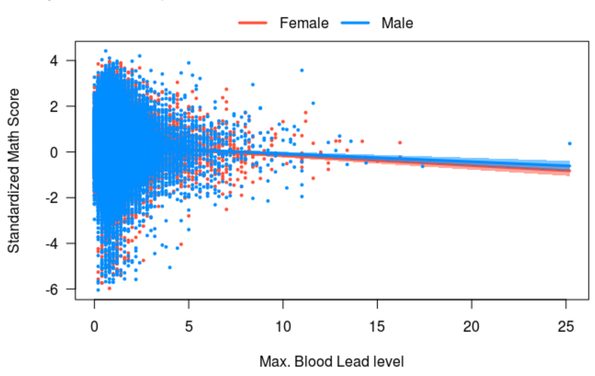
Elastic net results from the first imputed dataset



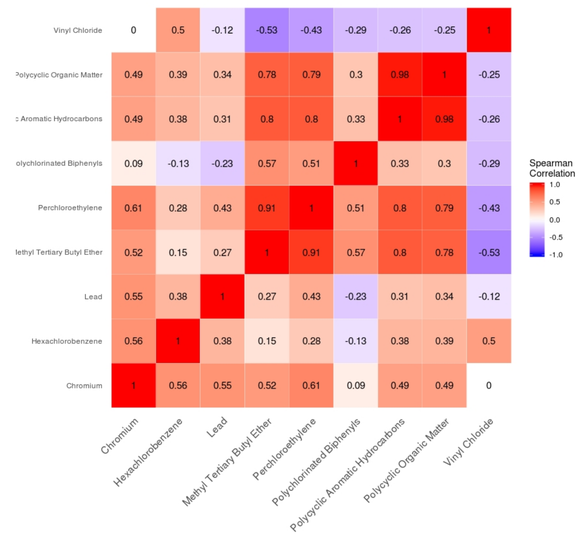
RESULTS

- For each 5 mcg/dL increase in blood lead, the standardized math score (Z-score) changes by -0.041 (95% CI: -0.049, -0.033) on average, adjusting for all potential confounders.
- Among those with less than 5 µcg/dL maximum venous blood lead, the standardized test score decreases by 3.1%, 1.7% and 2.4% on average with 1 µg/m^3 increase in PCB, Perchloroethylene and Methyl Tertiary Butyl Ether respectively, adjusting for all potential confounders.

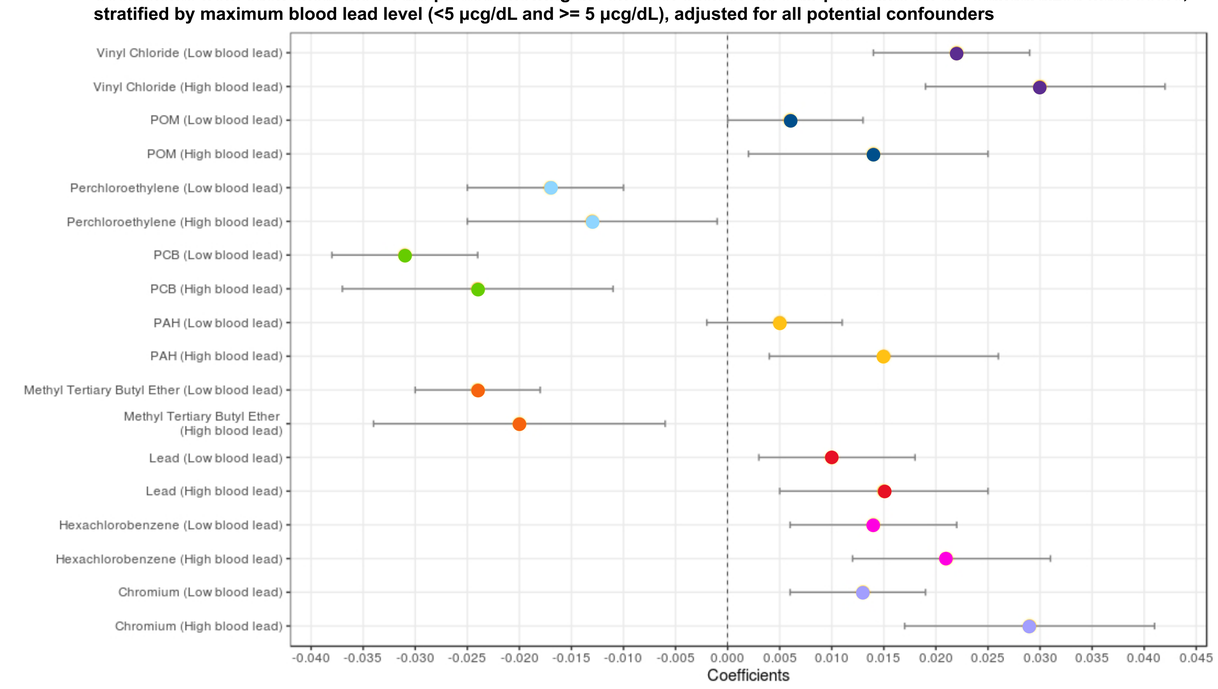
Linear regression showing the association between maximum blood lead level and standardized math score stratified by child sex, adjusted for all potential confounders



Heatmap visualizing the correlation matrix between the 9 air pollutants



Coefficients from each linear model are plotted showing the effect of each of the 9 air pollutants on the standardized math score, stratified by maximum blood lead level (<5 µcg/dL and >= 5 µcg/dL), adjusted for all potential confounders



CONCLUSIONS

- The slope indicating the change in standardized test scores with each 1 µg/m^3 varies by maximum blood lead level; adjusting for all potential confounders.
- The slope indicating the decrease in standardized test scores with each 1 µg/m^3 increase in Perchloroethylene, PCB and Methyl Tertiary Butyl Ether is steeper among those with <5 µg/dL maximum blood lead level; adjusting for all potential confounders
- Vinyl Chloride is inversely correlated with all other air pollutants. More advanced statistical methods are needed to better understand co-exposures of multiple air toxins.

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REFERENCES

[1] Stingone, J. A., McVeigh, K. H., & Claudio, L. (2016). Association between prenatal exposure to ambient diesel particulate matter and perchloroethylene with children's 3rd grade standardized test scores. *Environmental research*, *148*, 144–153. doi:10.1016/j.envres.2016.03.035

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