Potential for Bias When Estimating Critical Windows for Air Pollution in Childrens Health

Ander Wilson

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Air Pollution and Children's Health

- Evidence that maternal exposures to air pollution are associated with:
  - decreased birth weight
  - increased risk of pre-term birth
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Air Pollution and Children's Health

- Evidence that maternal exposures to air pollution are associated with:
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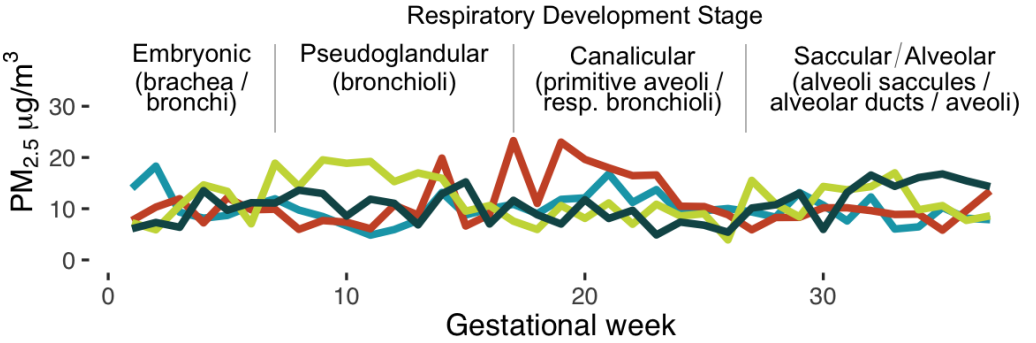
  - increased risk of pre-term birth
  - increased rates of childhood asthma and wheeze
- What is the best method for estimating this association and identifying critical windows?

Critical Windows of Vulnerability

Definition

A period in time during which there is an increased association between exposure and a future health outcome.

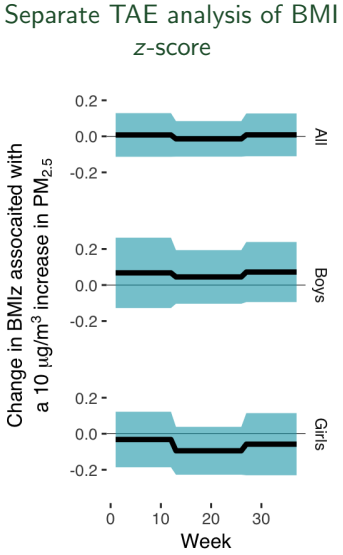


Trimester Average Exposure (TAE) Models

- Most common approach
- *Separate TAE* models
  - separate model for each trimester (q)

$$Y_i = \mu + \beta_q TAE_{iq} + Z_i^T \gamma + \epsilon_i$$

- Pre-specified potential windows corresponding to trimesters



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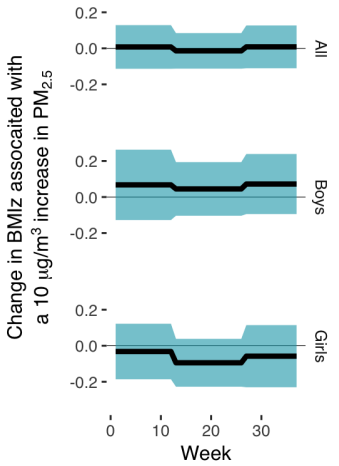
- Pre-specified potential windows corresponding to trimesters
- Alternative *joint TAE* model

$$Y_i = \mu + \sum_{q=1}^{3} \beta_q TAE_{iq} + Z_i^T \gamma + \epsilon_i$$

Separate TAE analysis of BMI *z*-score

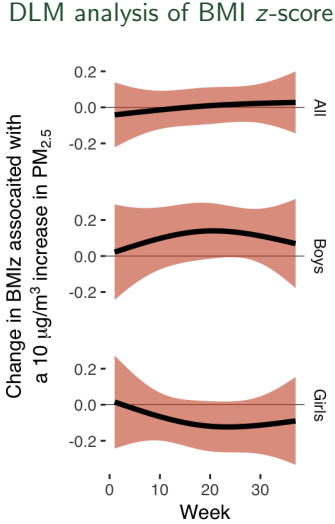


Distributed Lag Model (DLM)

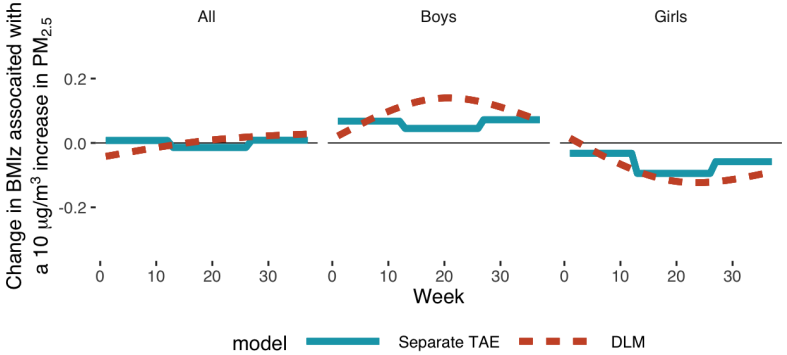
- Simultaneous analysis of exposure at all time points

$$Y_i = \mu + \sum_{t=1}^{T} \theta_t X_{it} + Z_i^T \gamma + \epsilon_i$$

- $\boldsymbol{\theta} = (\theta_1, \ldots, \theta_T)^T$ smooth
  - e.g. natural spline, Gaussian process, etc.
- Let the data define the windows



$PM_{2.5}$ Exposure and BMI z-score: Separate TAE vs DLM

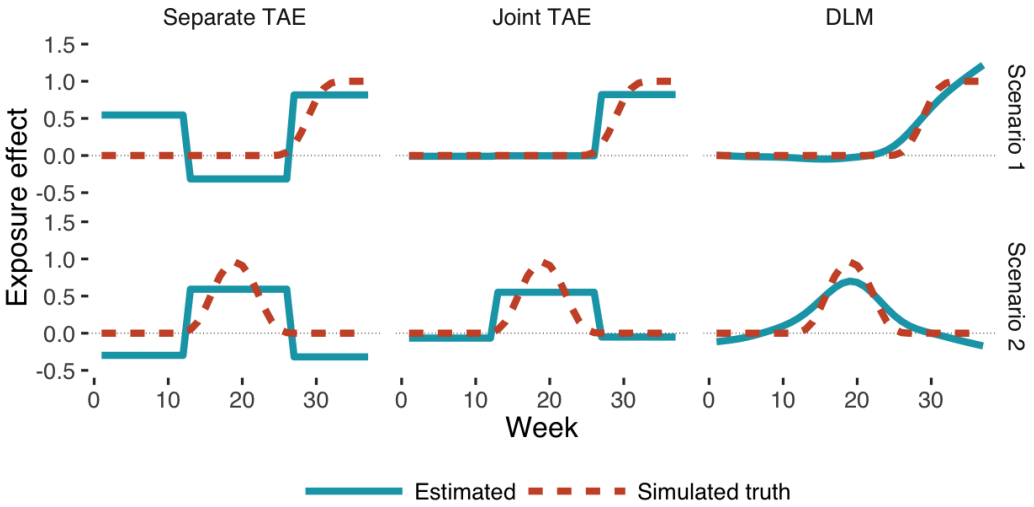


- Data from the ACCESS perinatal cohort in Boston, MA, USA ($n = 238$)
- Weekly $PM_{2.5}$ exposures at maternal residence
- Controls for maternal pre-pregnancy BMI, age, education, race/ethnicity, atopy, self, reported smoking during pregnancy, stress index, neighborhood disadvantage index, season of birth, and child sex (overall only)

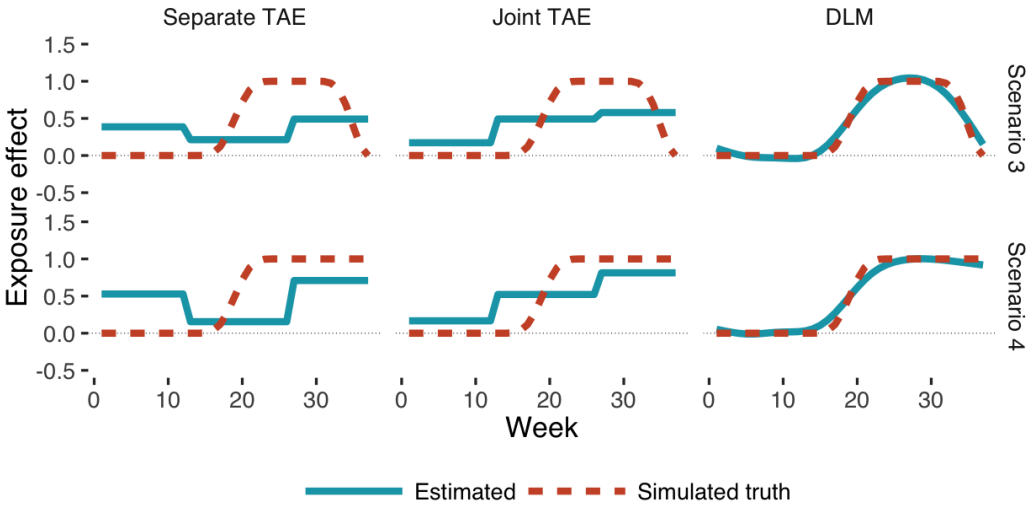
Test with Simulation

- Use real exposures and sample size from ACCESS data ($n = 238$)
- Simulate outcome from DLM with Gaussian errors
- 1000 simulated data sets
- No other biases:
  - No covariates that influence outcome
  - No confounders
  - No seasonal trends in outcome besides those explained by exposure
  - No measurement error

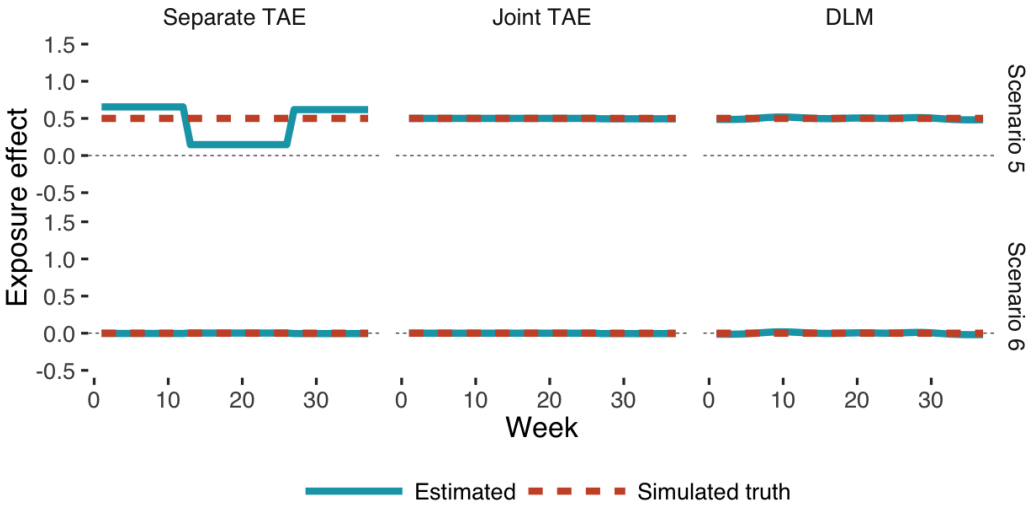
Simulation: Window is a Trimester



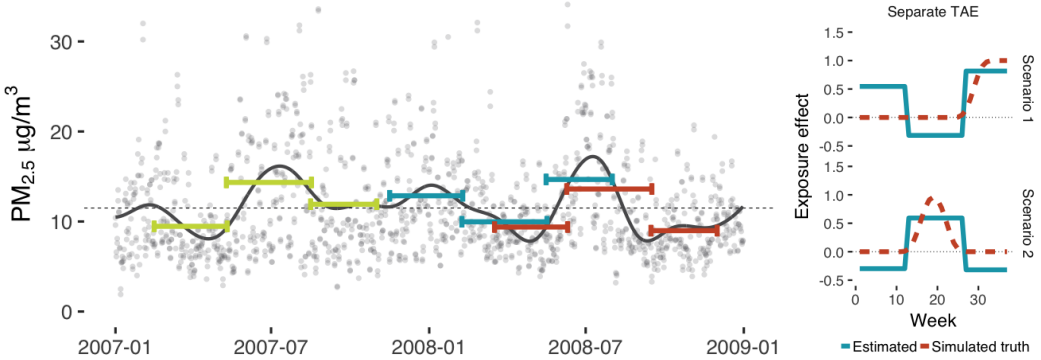
Simulation: Window is Not a Trimester



Simulation: Flat or Null



Seasonality and Confounding



$$\text{cor}\left[\begin{pmatrix} TAE_1 \\ TAE_2 \\ TAE_3 \end{pmatrix}\right] = \begin{pmatrix} 1.00 & & \\ -0.34 & 1.00 & \\ 0.66 & -0.40 & 1.00 \end{pmatrix}$$

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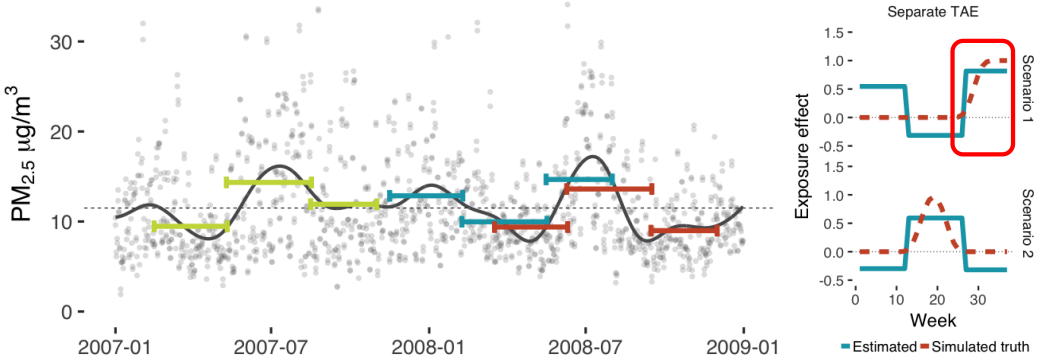

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Simulation Recap

- Separate TAE model can result in biased estimates
- Bias arises due to seasonal trends that induce correlation between trimesters which act as confounders
- Joint TAE was sometimes biased but generally had the correct pattern
- DLM performed best overall
- No bias in any method when no true exposure effect

Thank You!

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