

HOW DOES CHILDHOOD EXPOSURE TO AIR POLLUTION AFFECT ADULT OUTCOMES?

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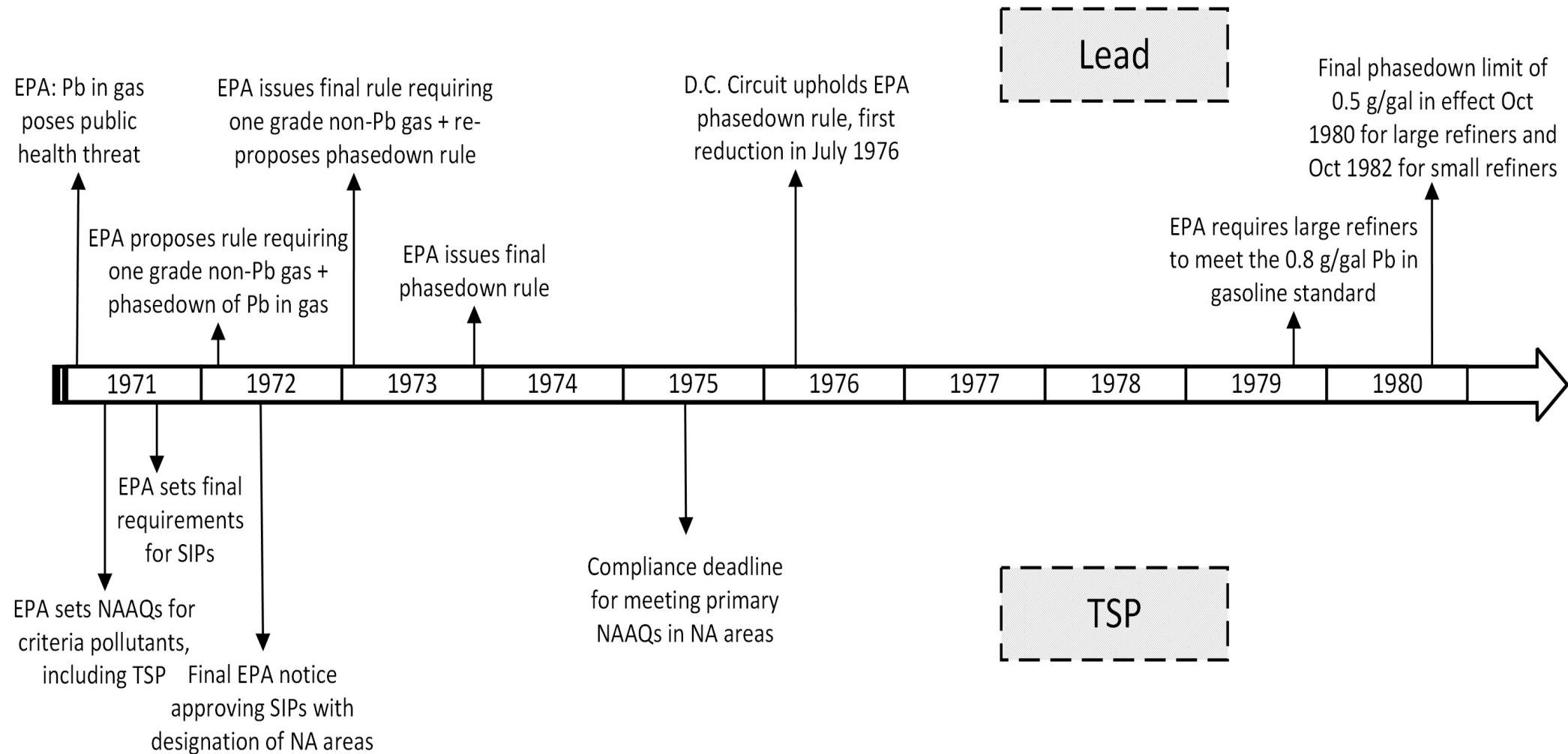
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*THE AUTHORS ARE WITH RESOURCES FOR THE FUTURE, THE MANHATTAN INSTITUTE, AND NATURAL RESOURCES CANADA, RESPECTIVELY.

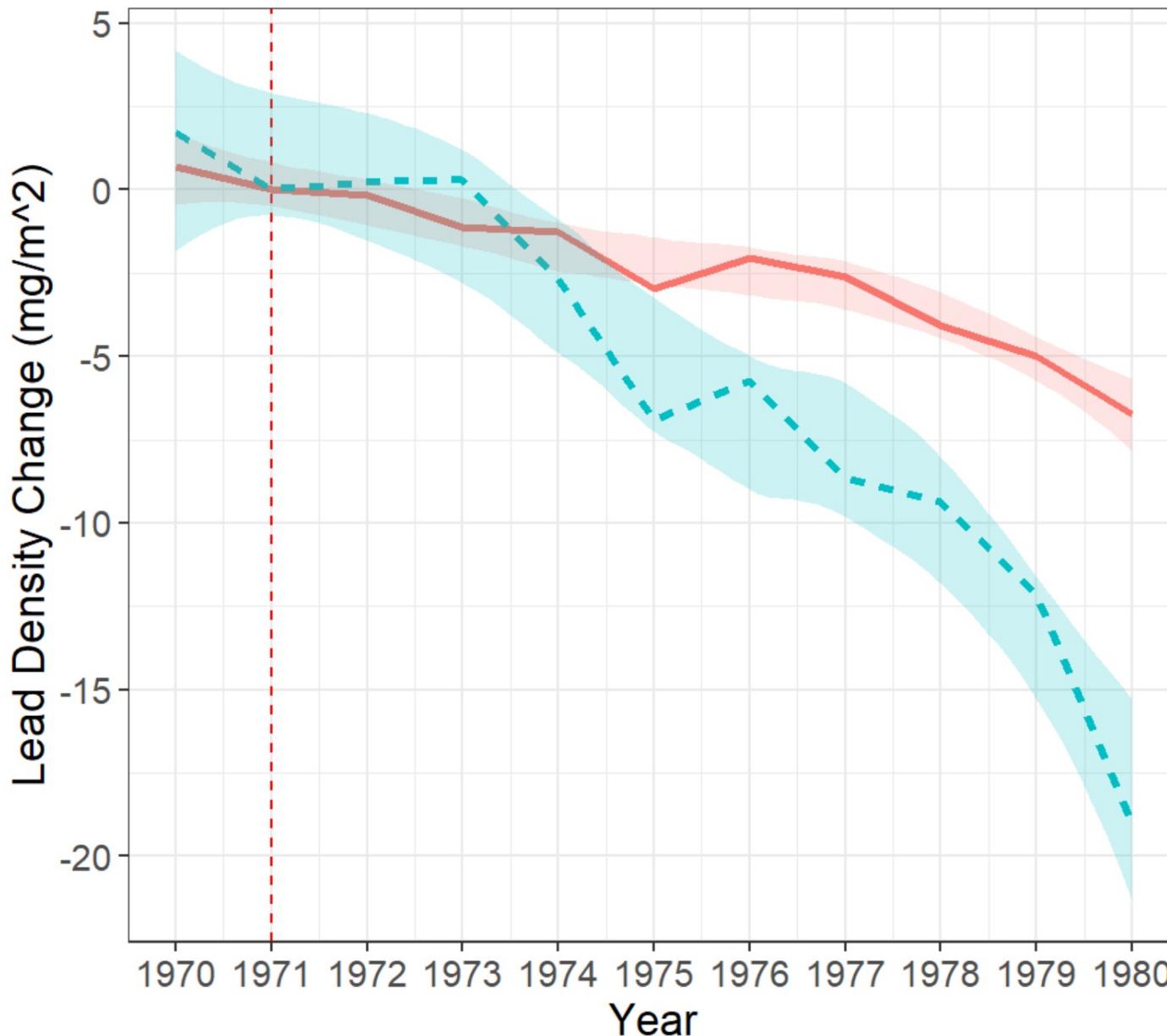
OVERVIEW

- Exposure to air pollution early in life may adversely affect adult outcomes, such as employment, earnings, crime, health, etc.
- Few studies establish a direct link between early life exposure and adult outcomes.
- Using data from an online personality survey, we study the impacts of early-life exposure to air pollution on the Big Five personality traits in adulthood.
 - Personality traits, e.g., conscientiousness, matter for labor market outcomes as well as social functioning / family stability, etc.
- We focus on people born during the 1970s, when there were dramatic reductions in air pollutants (lead from motor vehicles, particulates from industrial sources) due to EPA regulations.

EPA CONTROLS ON PARTICULATES & PB IN THE 1970S



Lead Density Change by TSP Classification



Lead density declines faster in counties classified as nonattainment under the 1972 TSP NAAQS than in counties classified as attainment with that NAAQS.

EPA's FR notice

- Attainment
- Nonattainment

148 U.S. counties studied by Isen et al, JPE 2017.

Note: Shading is 95% confidence interval. San Francisco is dropped due to its extreme lead density values.

KEY PRIOR ARTICLES

Schwaba et al (PNAS 2021)

- Use data from online personality survey (Gosling Potter Internet Personality Project), including childhood zip code and >1,000,000 U.S. respondents.
- Found significant associations, consistent with prior hypotheses, between childhood exposure to airborne Pb (through age 18) and adult personality traits: those with higher childhood Pb exposure were less agreeable, conscientious (and, for younger adults, more neurotic as adults)
- Main results controlled for age, parent's college, county-level income, but not for unidentified county-level or cohort effects.

KEY PRIOR ARTICLES

Isen et al (JPE 2017)

- Used data for adult labor market outcomes linked to birth county from the U.S. Census Bureau (LEHD)
- Found that birth-year exposure to particulate pollution (TSP) reduces employment and earnings at age 30.
- Identified causal effects, by comparing cohorts born before/after designation of counties as nonattainment with TSP NAAQS
- Did not consider impacts of Pb. We find counties that did not attain TSP NAAQS in early 70s also experienced larger reductions in Pb during the 1970s – possible omitted variable?

CONTRIBUTIONS

We build on Schwaba et al (2021) using their data on personality traits:

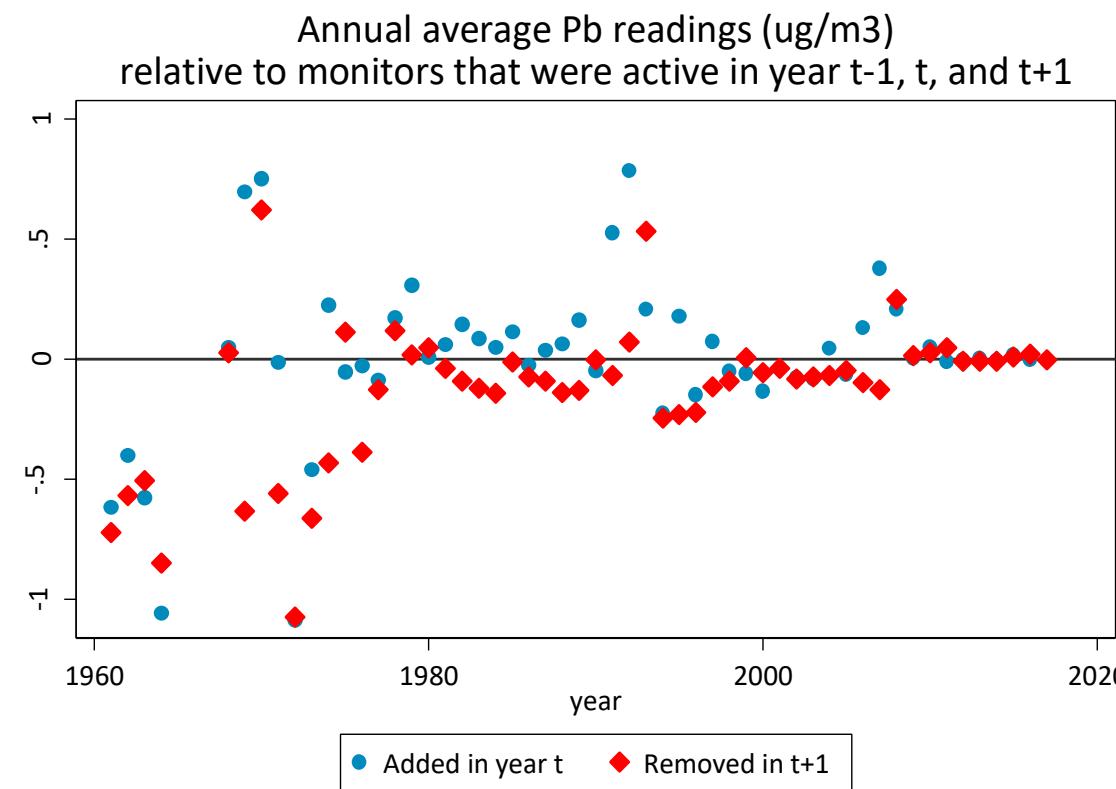
1. Develop improved measure of childhood Pb exposure using motor vehicle emissions
 - Pb monitoring data are sparse & reflect strategic placement of monitors.
 - Schwaba et al's main results are sensitive to imputation methods
2. Per Pb epi literature, we examine cumulative exposure over first 5 years (including the birth year).
3. Improve estimates, more fully leveraging the phase down of Pb in gasoline
 - Link personality traits explicitly to Pb content of gasoline
 - Introduce county and cohort fixed effects
 - Provide preliminary exposure-response for each Big-5 personality trait.

POLICY CONTEXT

- Lead control policy is still important today because of ongoing exposure from soils, paint in older homes, & drinking water pipes (e.g., Flint, MI).
- EPA has long set Pb standards partly by combining modeled estimates of childhood exposure on IQ and effects of IQ on adult earnings.
- Childhood Pb exposure affects behavioral issues & personality traits.
- EPA's analyses of Pb regulations do not quantify non-cognitive personality traits, e.g., agreeableness and conscientiousness—although these matter for labor market outcomes as well as social functioning / family stability, etc.

LIMITATIONS OF PB MONITORING DATA

- Lead monitoring was very intermittent, with very few long-term monitors
 - <200 counties had Pb monitors for most of the 1970s
 - Schwaba et al used complex interpolations to derive annual Pb series for each county
- Partial annual coverage and seasonality may imply measurement error. Most monitors took <50 daily readings per year.
- The Pb monitor network was operated to detect high concentrations, while avoiding the cost of monitoring at locations with low readings (figure on right)
 - County-level Pb trends may be biased, as locations with low readings tended to drop out



ESTIMATING PB EMISSIONS FROM VEHICLES

- We estimate lead emissions density (milligrams / m²) for each county & year, using:
 - Monthly gasoline volume sold, by state, by grade (Ethyl Corp)
 - Lead concentration by grade, by season, by marketing district (DOE)
 - Annual NO_x from motor vehicles by AQCR and by state (EPA's NEDS)
 - County land area (Census Bureau)
- We apportion
 - Statewide emissions to AQCRs based on share of statewide vehicular NO_x
 - AQCR-wide emissions to counties based on population

COMPARISON TO EPA'S LEAD-DUST STANDARD

- Our estimates of Pb emissions density from motor vehicles in the early 1970s were much higher than EPA's lead-dust standards for floors (first set in 2001), which focused on reducing lead exposure in older homes with lead paint.
 - Specifically, annual vehicular Pb emissions densities had a very wide range, from a fraction of one mg /m², up to 11,600 mg /m² in Manhattan in 1974.
 - EPA lowered the lead-dust standard, from 40 µg / ft², or 0.431 mg /m², to 10 µg / ft² in December 2020.

CORRELATION WITH MONITORED LEAD DATA

- For this comparison, we use counties in Schwaba et al, and focus on years 1969-1979.
- We regress the simple average of monitored levels within a county-year on our new measures of lead density, in logs.
- Results:
 - Highly statistically significant effects
 - Model uses dummies for 11 years and 251 counties, $n = 2761$.
 - $R^2 = 0.603$.

SCHWABA ET AL: HYPOTHESES AND FINDINGS

Trait	Hypotheses w/ Higher Pb exposure	Results: Higher Pb
Agreeableness	Lower Agreeableness	Less Agreeable
Conscientiousness	Lower Conscientiousness	Less Conscientious
Openness	Lower Openness	More Open
Extraversion	Not Stated	More Extraverted
Neuroticism	Higher Neuroticism	More Neurotic (only among younger people)

REPLICATION OF SCHWABA ET AL

- Examined the effect of childhood Pb exposure by linking atmospheric Pb monitoring data for 269 counties with data on adult Big Five personality traits for 1.5 million subjects.
- Used EPA Pb air monitoring data covering a period from 1960 to 2018, with interpolations and extrapolations.
- Schwaba et al. pre-registered their study with the Center for Open Science (COS), & provided us with their data and code.
- We have replicated their main results (using their code).

IMPROVEMENTS ON SCHWABA ET AL

- For agreeableness, starting from Schwaba et al's main specification, we have tested different controls (e.g., county FE, cohort FE), exposure periods & lead measures,
- Preliminary findings
 - Steeper & more consistent exposure response with FEs
 - Shorter exposure window predicts as well
 - Density measure performs as well.

		(1)	(2)	(3)	(4)	Agr
log(Lead exposure+1)		-0.032 ** (-0.066, 0.002)	-0.022 *** (-0.042, -0.002)	-0.082 *** (-0.162, -0.001)		
log(Lead density (unadj)+1)						-0.087 *** (-0.142, -0.032)
Age		0.026 *** (0.025, 0.027)	0.026 *** (0.025, 0.027)	0.027 *** (0.025, 0.029)		0.027 *** (0.025, 0.029)
Parent College		-0.014 *** (-0.019, -0.008)	-0.014 *** (-0.019, -0.008)	-0.040 *** (-0.054, -0.025)		-0.040 *** (-0.054, -0.025)
Median County Income		-0.161 *** (-0.182, -0.141)	-0.161 *** (-0.182, -0.141)	-0.247 *** (-0.312, -0.183)		-0.207 *** (-0.278, -0.136)
Timeframe	18years	5years	5years	5years	5years	
Cohort	all	all	1969-1977	1969-1977	1969-1977	
Avglead	0.18	0.43	0.99	0.99	0.99	510.95
Sdlead	0.33	0.57	0.54	0.54	0.54	914.72
Observations	1,059,813	1,059,813	132,383	132,383	132,383	
R ²	0.014	0.014	0.018	0.018	0.018	
Adjusted R ²	0.014	0.014	0.016	0.016	0.016	

HYPOTHESES AND PRELIMINARY FINDINGS

Trait	Hypotheses w/ Higher Pb exposure	Schwaba Results: Higher Pb	Fraas, Lutter & Murphy: Higher Pb
Agreeableness	Lower Agreeableness	Less Agreeable	Less Agreeable
Conscientiousness	Lower Conscientiousness	Less Conscientious	Less Conscientious
Openness	Lower Openness	More Open	More Open
Extraversion	Not Stated	More Extraverted	More Extraverted With More Ambient Pb, with FEs & 5 year exposure window, but no Effects of Pb Density in 1970s.
Neuroticism	Higher Neuroticism	More Neurotic (only among younger people)	Less Neurotic (**) With More Ambient Pb, with FEs & 18 year exposure window, but More Neurotic (**) with More Pb Density & 5 year exp window.

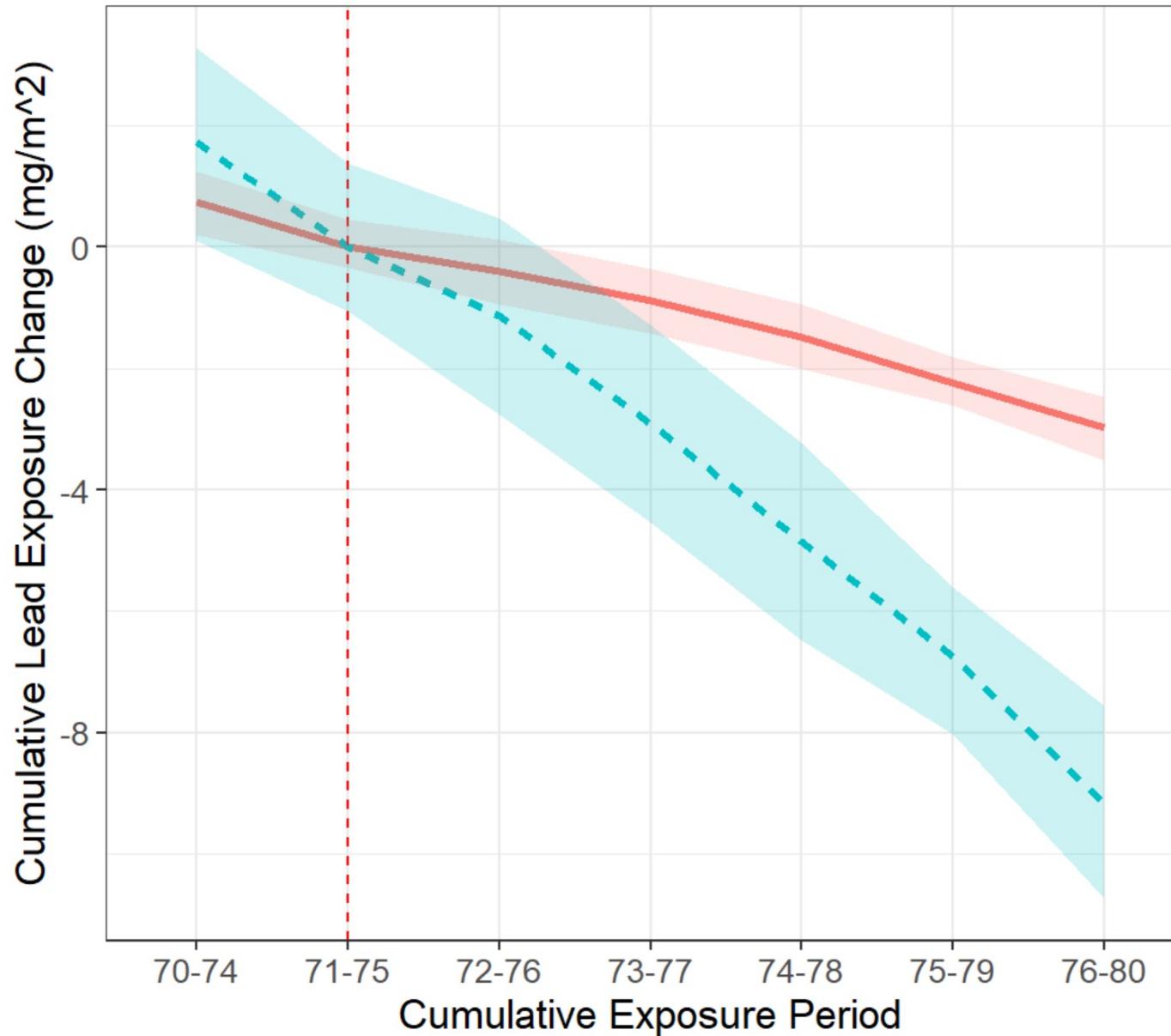
CONCLUSIONS

- Long term effects of pollution on adult outcomes are hard to estimate but may be important.
- Estimating such effects in a manner to support better designed policies requires
 - Estimating full effects of pollution, including, e.g., effects of lead on personality traits, and
 - Disentangling effects of separate pollution exposures.
- Our results raise questions about importance of controlling for changes in Pb exposure over the period from 1960s to 1980 in assessing effects of PM & O₃ on adult outcomes.

NEXT STEPS

- Short Run:
 - Explore further alternative functional forms, especially steeper exposure-response relationships at lower exposure levels
 - Focus on population-oriented monitors
 - Test how exogenous changes in TSP concentrations may influence adult personalities
- Long Run
 - Consider how new Pb density measure may predict other adult outcomes, including labor market outcomes.
 - Explore more disaggregated measures of lead density & exposure, e.g., zip code.

Cumulative Lead Density (Exposure) Change by TSP Classification



EPA's FR notice

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- Nonattainment

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Each cumulative exposure period represents the first five full calendar years of life for children born in prior year. For example, 70-74 refers to the 1969 birth cohort.