Ashes to Ashes: The Lifelong Consequences of Early-Life Wildfire Exposure

Seth Neller (Job Market Paper)
Samuel Arenberg

Introduction

Air pollution increases contemporaneous mortality of both the very old and very young, in addition to causing many other issues (e.g., lower labor force participation, poor schooling outcomes, increased crime).

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Less is known about how the harms of air pollution exposure during early childhood manifest in reduced well-being and longevity in later adulthood.

Importance: long-run effects frequently comprise a large fraction of the damages from early-life shocks (Currie and Almond, 2011; Almond et al., 2018).

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▶ Quantifying the effects of air pollution substantially past early adulthood (through age 59) $\implies$ later-life dynamics are quite important!

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▶ Quantifying the effects of air pollution substantially past early adulthood (through age 59) $\implies$ later-life dynamics are quite important!
▶ Studying long-term effects of a source of air pollution that is growing globally and that also may be very harmful.

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Very long-run estimates have been previously unmeasured due to data limitations.

Outcomes

Treatment + Variation

Linkage

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California Wildfire
"Fire Atlas" Data
1930-1969
[CALFIRE]

Supplement dates with
archived newspaper
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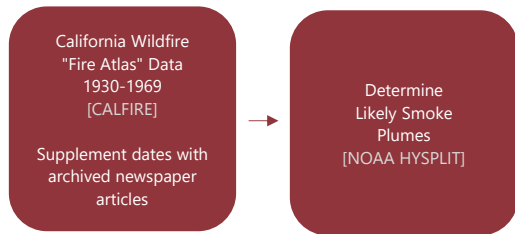
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Link to Adult Economic
Achievement,
Education, & Disability
[Census/ACS]

$\implies$ Leverage variation in smoke exposure to identify long-run effects within a cohort distributed lags/leads framework

## Estimating Equations for Long-Run Outcomes
Distributed Lags/Leads Model

$$Y_{icba} = \underbrace{\mu_c}_{\substack{\text{Birth} \\ \text{City}}} + \underbrace{\lambda_{y(b),r(c)}}_{\substack{\text{YOB} \times \\ \text{Region}}} + \underbrace{\alpha_{m(b)}}_{\substack{\text{Calendar} \\ \text{MOB}}} + \underbrace{\psi_{y(b),a}}_{\substack{\text{YOB} \times \\ \text{Age @} \\ \text{Survey*}}} + \sum_{k=-5}^{5} \underbrace{\delta_k Smoke_{c,b+k}}_{\substack{\text{\# of Months w/} \\ \text{Any Smoke} \\ \text{Exposure During} \\ \text{Period } b + k}} + \varepsilon_{icba},$$

- ▶ Unit of analysis is individual i, born in city c, born in year-month b, observed at age a^*.
- ▶ Identifying assumption is that, conditional on controls, highly exposed units would comparable to less-exposed units, absent treatment.

* if applicable

Estimating Equations for Long-Run Outcomes
"Summary" Model

$$Y_{icba} = \underbrace{\mu_c}_{\substack{\text{Birth} \\ \text{City}}} + \underbrace{\lambda_{y(b),r(c)}}_{\substack{\text{YOB} \times \\ \text{Region}}} + \underbrace{\alpha_{m(b)}}_{\substack{\text{Calendar} \\ \text{MOB}}} + \underbrace{\psi_{y(b),a}}_{\substack{\text{YOB} \times \\ \text{Age @} \\ \text{Survey*}}} + \underbrace{\delta \cdot Smoke_{cb}^{\text{IU-Age4}}}_{\substack{\# \text{ of Months w/ Any} \\ \text{Smoke Exposure} \\ \text{through Age 4}}} + \varepsilon_{icba},$$

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Results
Description of Figure
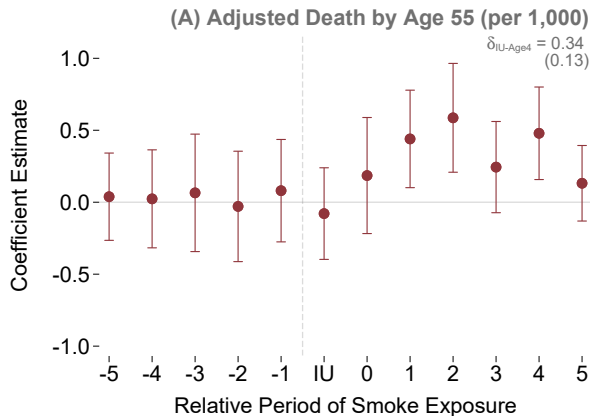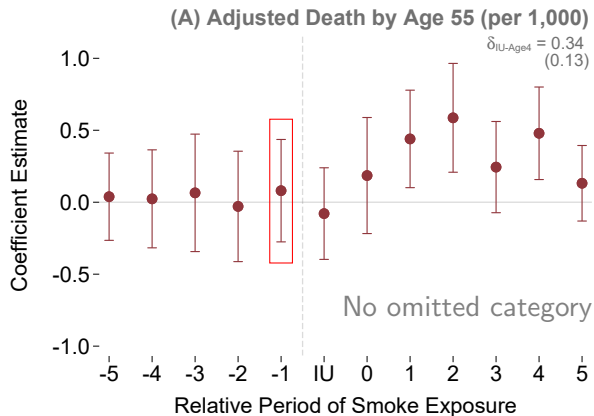
(A) Adjusted Death by Age 55 (per 1,000)

$\delta_{\text{IU-Age4}} = 0.34$
(0.13)

Each coefficient in the graph represents the effect of an additional month with any smoke exposure *during that age bin* (and conditional on exposure at other ages).

(A) Adjusted Death by Age 55 (per 1,000)

$\delta_{\text{IU-Age4}} = 0.34$
(0.13)

No omitted category

Relative Period of Smoke Exposure

Coefficient Estimate

Each coefficient in the graph represents the effect of an additional month with any smoke exposure *during that age bin* (and conditional on exposure at other ages).

Results

Wildfire Exposure Reduces Survival to Age 55, Conditional on Surviving Past Early Childhood

(A) Adjusted Death by Age 55 (per 1,000)

$\delta_{\text{IU-Age4}} = 0.34$
(0.13)
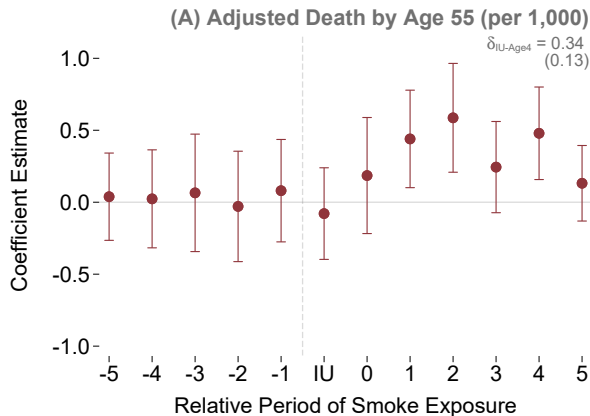
An additional month of smoke exposure during *in utero* through Age 4 results in 0.34 additional deaths before age 55 per 1,000 ($p_{25} \rightarrow p_{75} = 1.7$).
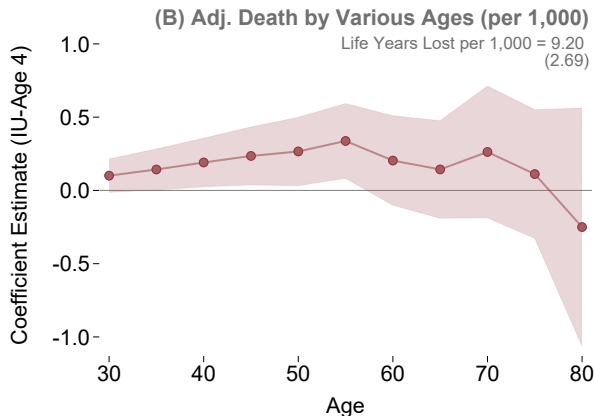
Results

Wildfire Exposure Results in Life Years Lost between Ages 30 and 80

(B) Adj. Death by Various Ages (per 1,000)

Life Years Lost per 1,000 = 9.20
(2.69)
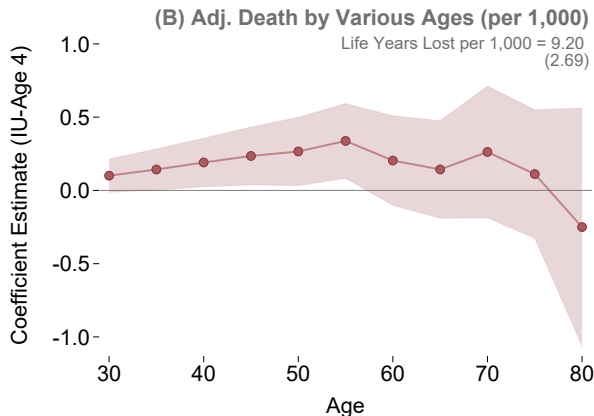
An additional month of smoke exposure during *in utero* through Age 4 results in 9.2 life years lost between ages 30 and 80 per 1,000 ($p_{25} \rightarrow p_{75} = 46$).

Results

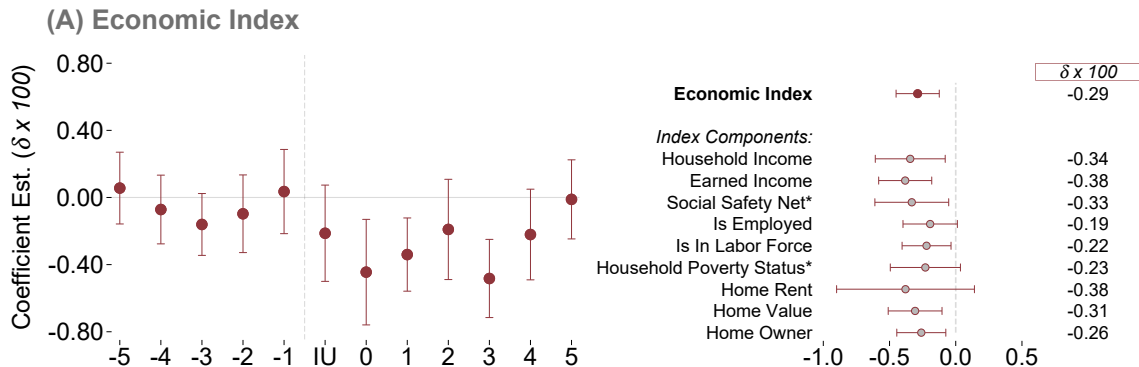Wildfire Exposure Results in Life Years Lost between Ages 30 and 80

(B) Adj. Death by Various Ages (per 1,000)

Life Years Lost per 1,000 = 9.20
(2.69)

For context: life years lost due to infant mortality within our sample ($p_{25} \to p_{75} = 11.7$ per 1,000 births) $\implies$ more years lost due to shortened adult lifespan.

Results

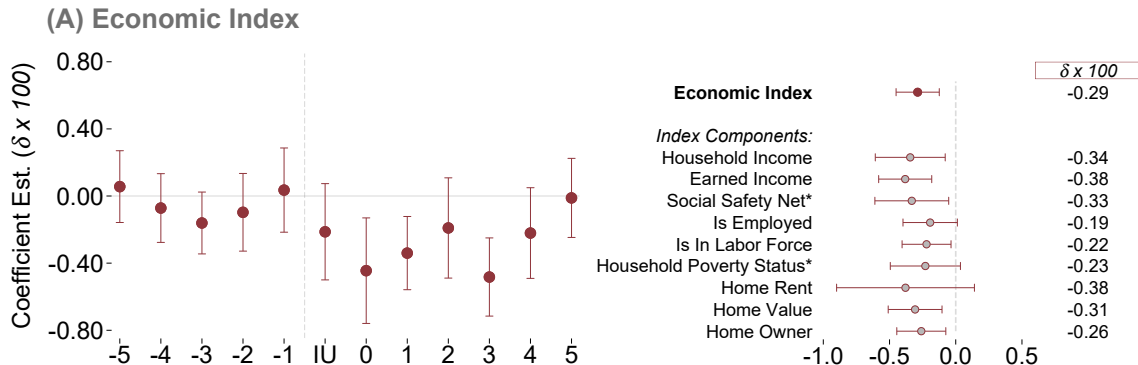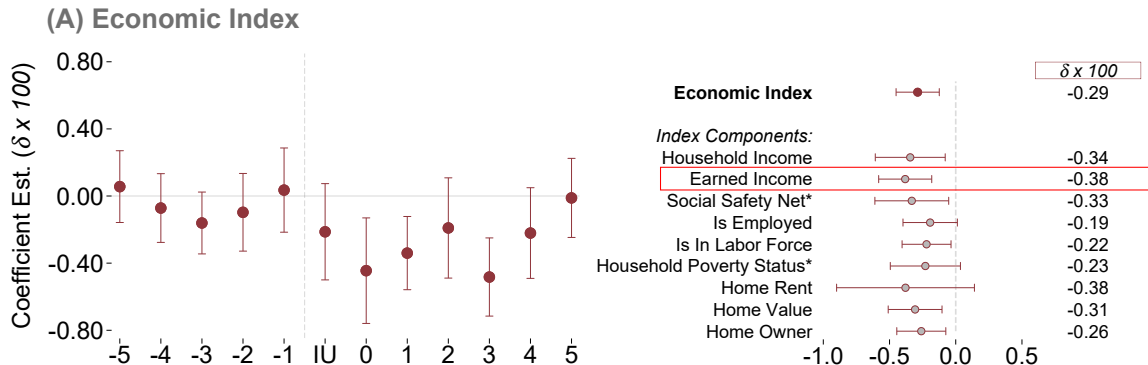Wildfire Exposure Reduces Later Life (Ages 35-59) Economic Achievement

(A) Economic Index

Results

Wildfire Exposure Reduces Later Life (Ages 35-59) Economic Achievement

(A) Economic Index

An additional month of smoke exposure during *in utero* through Age 4 results in a ↓ 0.29% of a standard deviation in economic achievement ($p_{25} \rightarrow p_{75} = 1.45\%$).
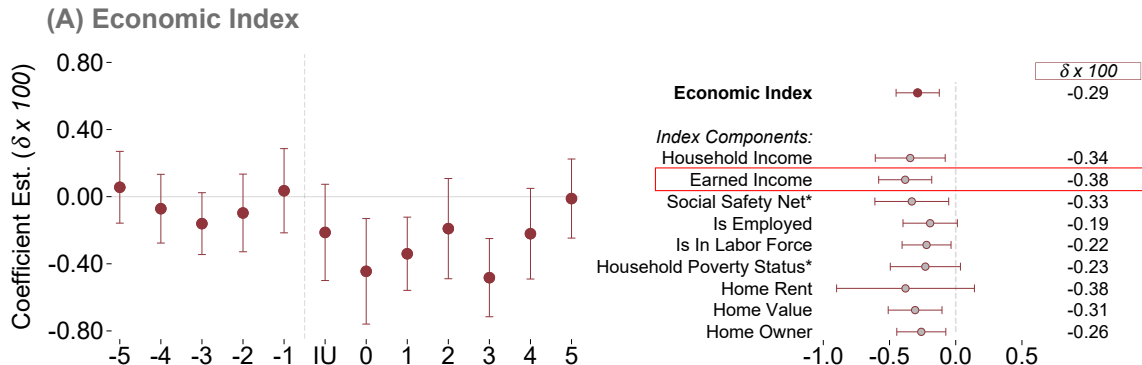
Results

Wildfire Exposure Reduces Later Life (Ages 35-59) Economic Achievement

(A) Economic Index

An additional month of smoke exposure during *in utero* through Age 4 results in a ↓ 0.38% of a SD [\$178] in earned income ($p_{25} \rightarrow p_{75} = \$890$).

Results

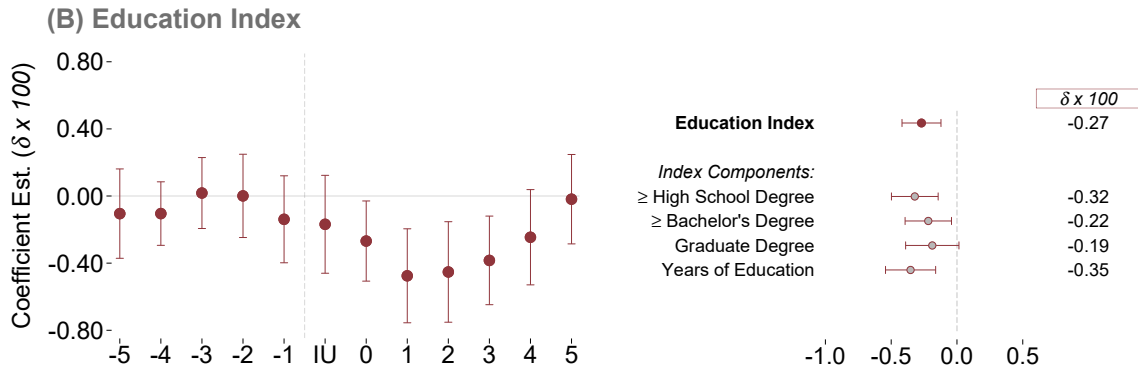Wildfire Exposure Reduces Later Life (Ages 35-59) Economic Achievement

(A) Economic Index

Economic losses as mechanism for ↓ mortality? ⟹ Use Chetty et al (2016) estimates × ↓ in earned income: no more than 59% of ↓ life expectancy explained by lost earnings.
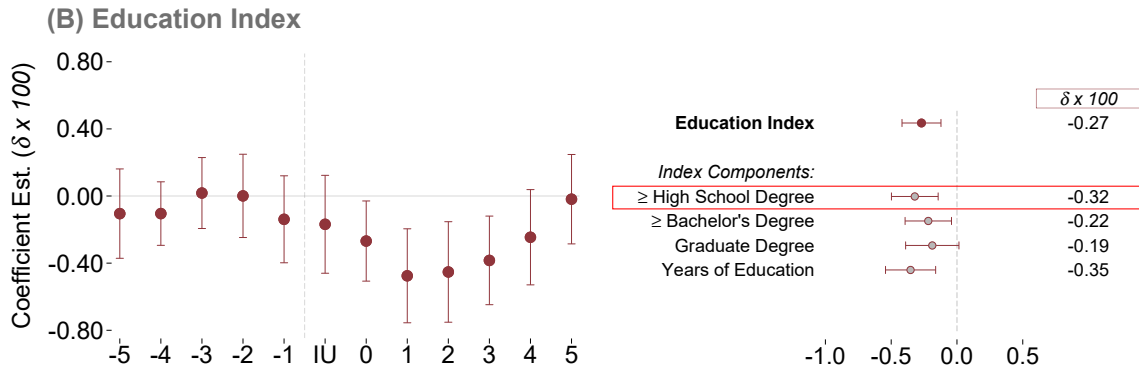
Results

Wildfire Exposure Reduces Later Life (Ages 35-59) Educational Attainment

(B) Education Index

An additional month of smoke exposure during *in utero* through Age 4 results in a ↓ 0.27% of a standard deviation in educational attainment ($p_{25} \rightarrow p_{75} = 1.35\%$).

Results
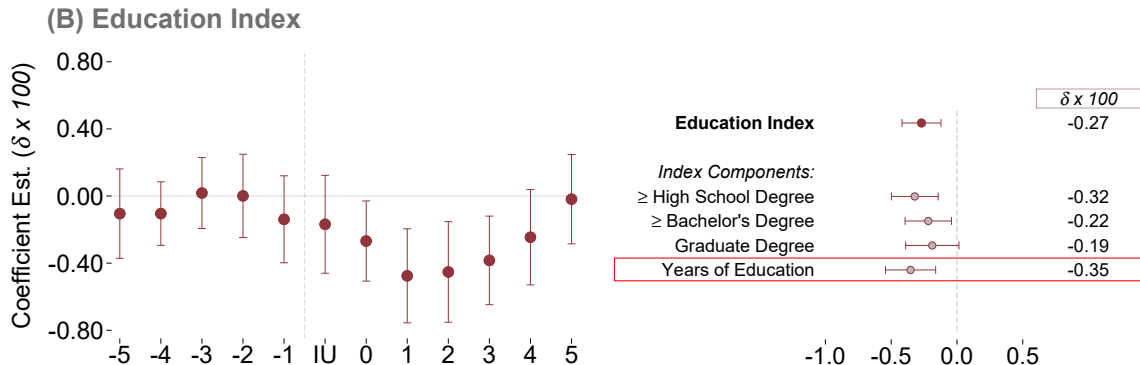Wildfire Exposure Reduces Later Life (Ages 35-59) Educational Attainment

(B) Education Index

An additional month of smoke exposure during *in utero* through Age 4 results in a ↓ 0.32% of a SD [0.08pp] in high school completion. ($p_{25} \rightarrow p_{75} = 0.40$pp).

Results

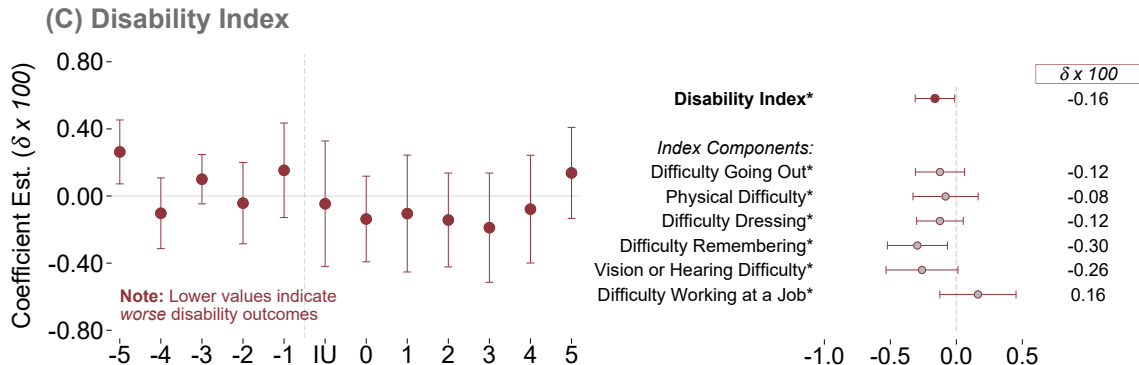Wildfire Exposure Reduces Later Life (Ages 35-59) Educational Attainment

(B) Education Index

	$\delta \times 100$
Education Index	-0.27
Index Components:	
≥ High School Degree	-0.32
≥ Bachelor's Degree	-0.22
Graduate Degree	-0.19
Years of Education	-0.35

Moving from p25→p75 yields 0.05 fewer years of education: using a 10% return, this roughly explains a 0.5% decrease in earnings (about 1/4 of the effect)

Results

(C) Disability Index
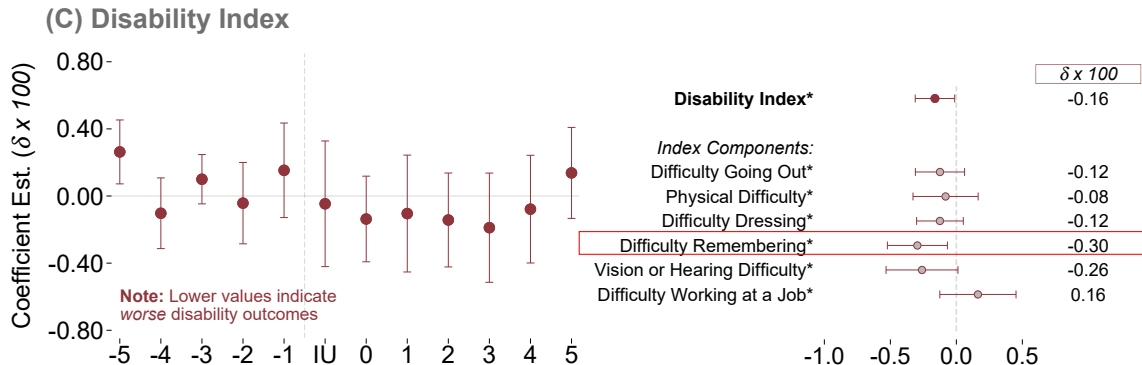
An additional month of smoke exposure during *in utero* through Age 4 results in a ↓ 0.16% of a standard deviation in disability index ($p_{25} \to p_{75} = 0.80\%$).

Results

(C) Disability Index

An additional month of smoke exposure during *in utero* through Age 4 results in a ↑ 0.30% of a SD [0.06pp] in difficulty concentrating/remembering. ($p_{25} \rightarrow p_{75} = 0.30$pp).

Supplemental Results: Effects by Age at Survey

How do effects of childhood air pollution exposure change as people age?

Supplemental Results: Effects by Age at Survey

(A) Earnings
(in 2010$)

(B) Difficulty Remembering
(in percentage points)
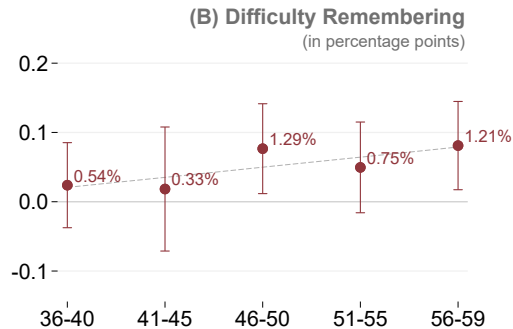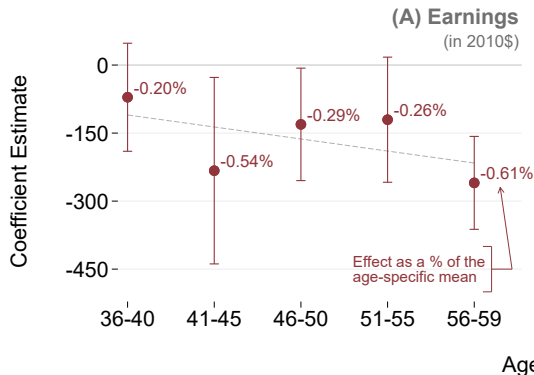
Harms from smoke exposure increase proportionally with age ⇒ assuming proportional harms from early-adult estimates will understate total costs.

The Cost and Fiscal Burden of Early-Life Wildfire Smoke Exposure

What costs would be avoided if we could "shut off" wildfires in our sample?

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What costs would be avoided if we could "shut off" wildfires in our sample?

(A) Lost Earnings and Life Years			(B) Fiscal Burden		
Earnings Loss (Discounted)	$	9,892	Lost Federal Tax Revenue (Discounted)	$	1,306
Life Years Lost (Longevity)	$	12,558	Additional Social Safety Net Costs	$	482
			Additional Incarceration Costs	$	99
Loss per Person	$	22,450	Fiscal Cost per Person	$	1,887
Loss per 500,000 Persons (in $B)	$	11.22	Fiscal Cost per 500,000 Persons (in $B)	$	0.94

Thank you!

seth.neller@gmail.com

Appendix I
References

Almond, D., J. Currie, and V. Duque (2018, December). Childhood Circumstances and Adult Outcomes: Act II. *Journal of Economic Literature 56*(4), 1360–1446.

Currie, J. and D. Almond (2011). Human Capital Development Before Age Five. In *Handbook of Labor Economics*, Volume 4, pp. 1315–1486. Elsevier.