Work from Home and Air Pollution

RWC, October 29th 2026

Benjamin Krebs (Basel)
Nick Bloom (Stanford)
Joshua Graff Zivin (UCSD)
Matthew Neidell (Columbia)

Well Known That The 2020 Lockdown Reduced City NO_2 Air Pollution

The New York Times

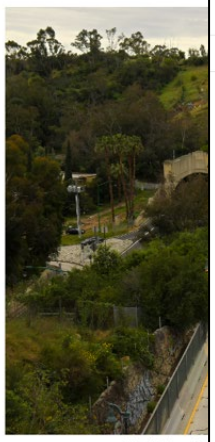
Traffic and Pollution Plummet as U.S. Cities Shut Down for Coronavirus

By Brad Plumer and Nadja Popovich March 22, 2020

In cities across the United States, traffic on roads and highways has fallen dramatically over the past week as the coronavirus outbreak forces people to stay at home and everyday life grinds to a halt.

Pollution has dropped too.

A satellite that detects emissions in the atmosphere linked to cars and trucks shows huge declines in pollution over major metropolitan areas, including Los Angeles, Seattle, New York, Chicago and Atlanta.



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Coronavirus Got Rid of Smog. Can Electric Cars Do So Permanently?

During a single week in March, New York City's emissions and carbon-monoxide levels dropped more than 50%. As similar phenomena occur in megacities worldwide, this could be a tipping point for electric-car sales



By Dan Neil
April 10, 2020 11:36 am ET

Gift unlocked article



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The Guardian

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Environment Climate crisis Wildlife Energy Pollution Green light

Coronavirus UK lockdown causes big drop in air pollution

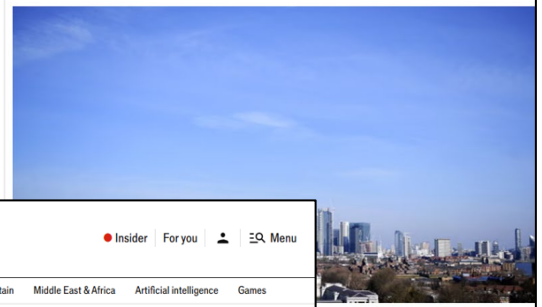
Air quality in big cities is likely to improve even more in coming weeks, say scientists

Coronavirus - latest updates
See all our coronavirus coverage

Damian Carrington
Environment editor
Fri 27 Mar 2020 05.32 EDT

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ea of London this week. Photograph:

onavirus outbreak has led to big
ities, new data analysis shows.

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Coronavirus: Air pollution and CO2 fall rapidly as virus spreads

19 March 2020

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Matt McGrath
Environment correspondent



Traffic has been much-reduced on the streets of New York

The Economist

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Graphic detail | Blue skies turn grey

Air pollution is returning to pre-covid levels

This bodes ill for respiratory health

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Sep 5th 2020 | 2 min read

COVID-19 IS NOT all bad, as any city-dweller who stepped outside this year will have seen. The virus has killed hundreds of thousands of people and decimated economies around the world. But as GDP has fallen so has air pollution. This spring marked the first time in decades that residents of Jalandhar in northern India were able to see the snow-capped Himalayan mountains, 160km (100 miles) away.

One particularly common pollutant is nitrogen dioxide (NO_2). The World Health Organisation (WHO) reckons that NO_2 levels above 40 micrograms in every cubic metre of air (40μg/m^3) are harmful to people. In Delhi, one of the world's most polluted big cities, NO_2 fell sharply after the city imposed its lockdown, from 46μg/m^3 in March to 17μg/m^3 in early April. Similarly, NO_2 levels in London fell from 36μg/m^3 in March to 24μg/m^3 two weeks later.

Likely Health Benefits as Pollution (e.g. NO_2) has Health Costs

Nitrogen dioxide (NO_2) is a reddish-brown, pungent gas that acts as a major air pollutant and a strong oxidizing agent. IQAir +1

Where It Comes From

- **Outdoor Sources:** Burning fossil fuels in motor vehicles (cars, trucks, and buses), power plants, and industrial equipment.
- **Indoor Sources:** Unvented gas stoves, kerosene heaters, wood-burning appliances, and tobacco smoke. U.S. Environmental Pro... +4

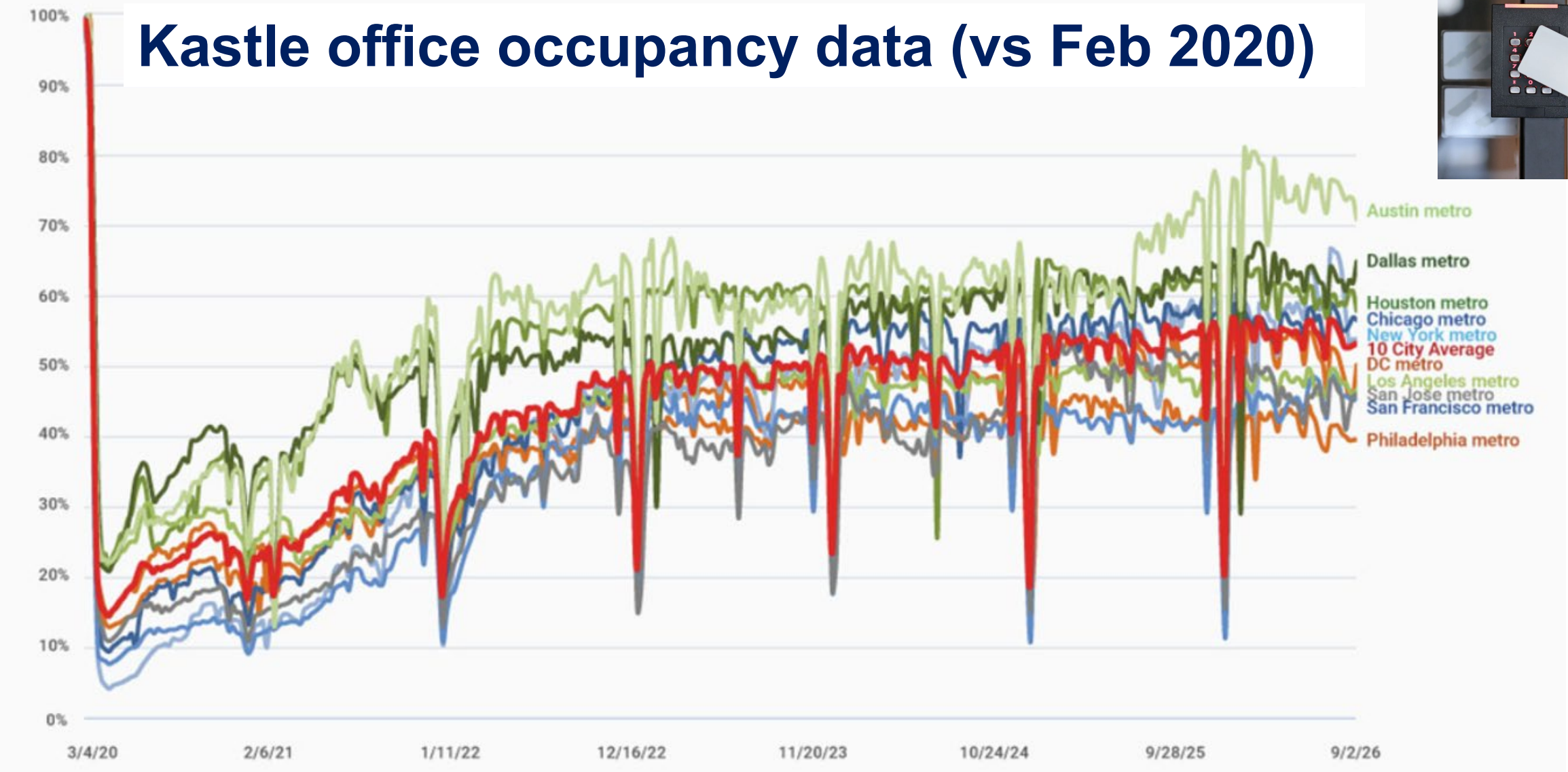
Health Effects

- **Respiratory System:** Irritates the airways, worsens asthma, causes coughing and wheezing, and reduces lung function.
- **Vulnerable Groups:** Children, the elderly, and people with pre-existing heart or lung conditions are most at risk. American Lung Associa... +1

Question: Did Better Air Quality Persist; is it due to Persistent WFH?



Kastle office occupancy data (vs Feb 2020)



Source: Kastle back to work Barometer, 2600+ buildings https://www.kastle.com/safety-wellness/getting-america-back-to-work/

This Paper Argues NO_2 Reductions did Persist, due to WFH

This paper uses satellite, demographic and commute data to show that

1) Nitrogen dioxide (NO_2) is 8% lower in large city centers in 2025 vs 2019

2) Fall in Nitrogen dioxide (NO_2)
   - Largest *across* 333 MSAs city centers with the greatest increase in WFH
   - Largest *within* city areas with greatest potential WFH induced fall in commuting

US EPA epidemiological model used as an illustrative magnitude implies this fall in NO_2 avoids about 1,500 to 3,500 deaths a year

Suggests WFH could provide broader benefits from reduced commuting pollution

Data

Pollution

Connection to WFH

Predicted Mortality Effects

Primary data is Satellite Informed NO_2 data

Uses the Tropospheric Monitoring Instrument on the ESA Sentinel-5 Precursor satellite, which measures columnic NO_2

Nawaz et al. (2025) combine with data on ground-level NO_2, land-use, and weather to predict monthly NO_2 at 1km x 1km.

NO_2 has short atmospheric life (daytime 5 to 8 hours) and is primarily created by high-temperature combustion (e.g. vehicles).



Sentinel 5 Precursor, Launched October 2017



Tropospheric Monitoring Instrument

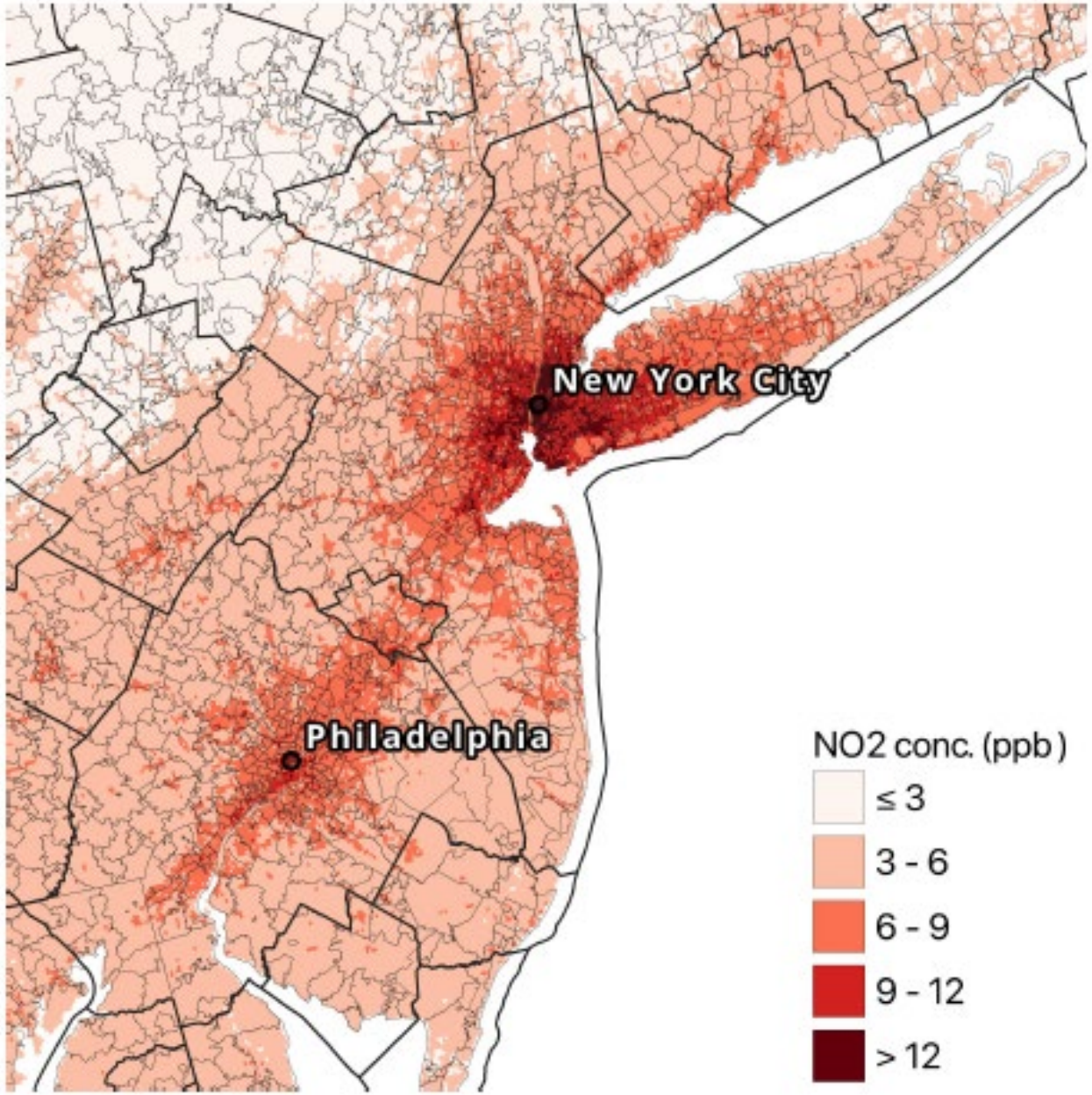
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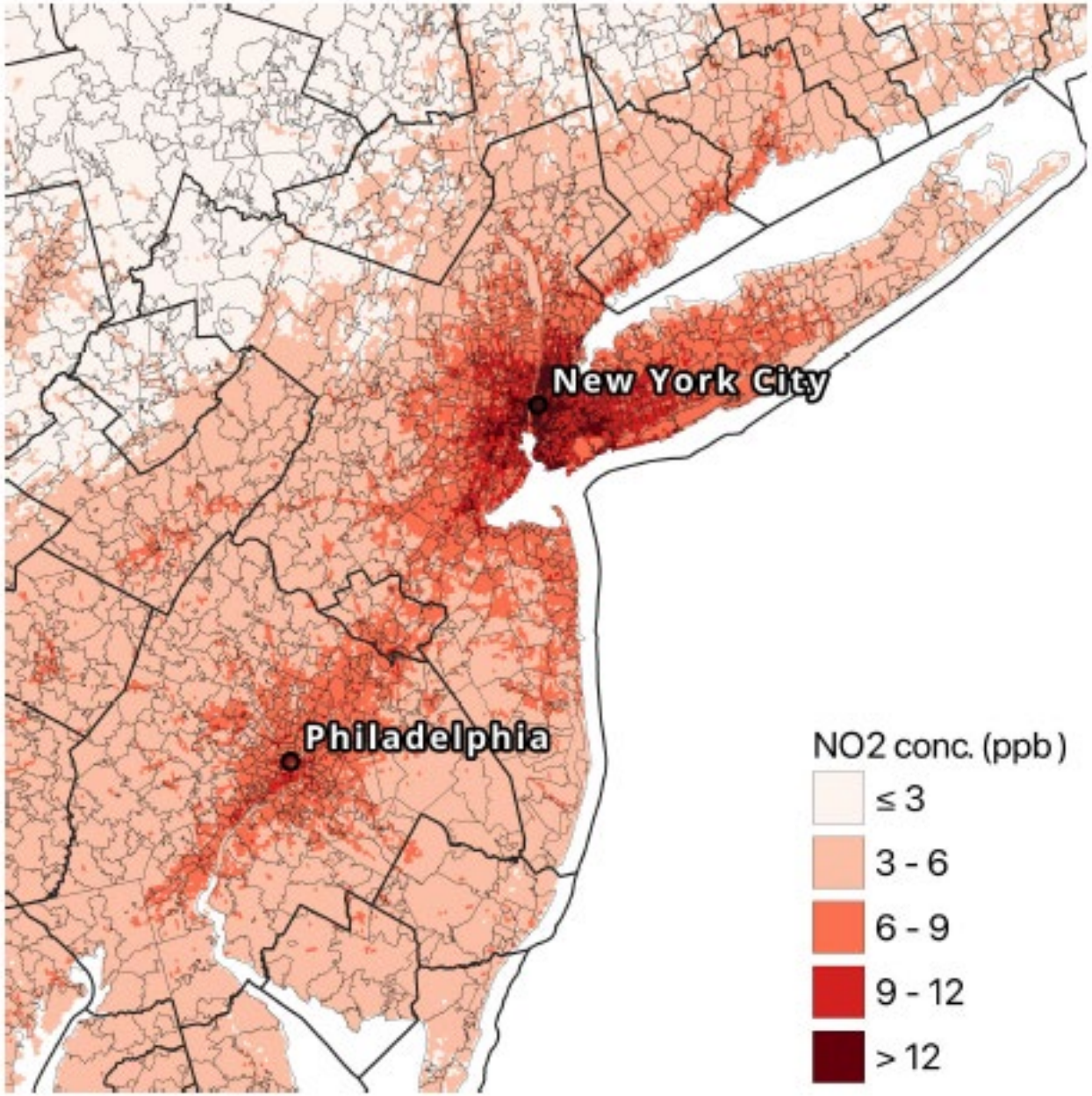
New York and Philadelphia NO_2 Air Pollution Map, 2019

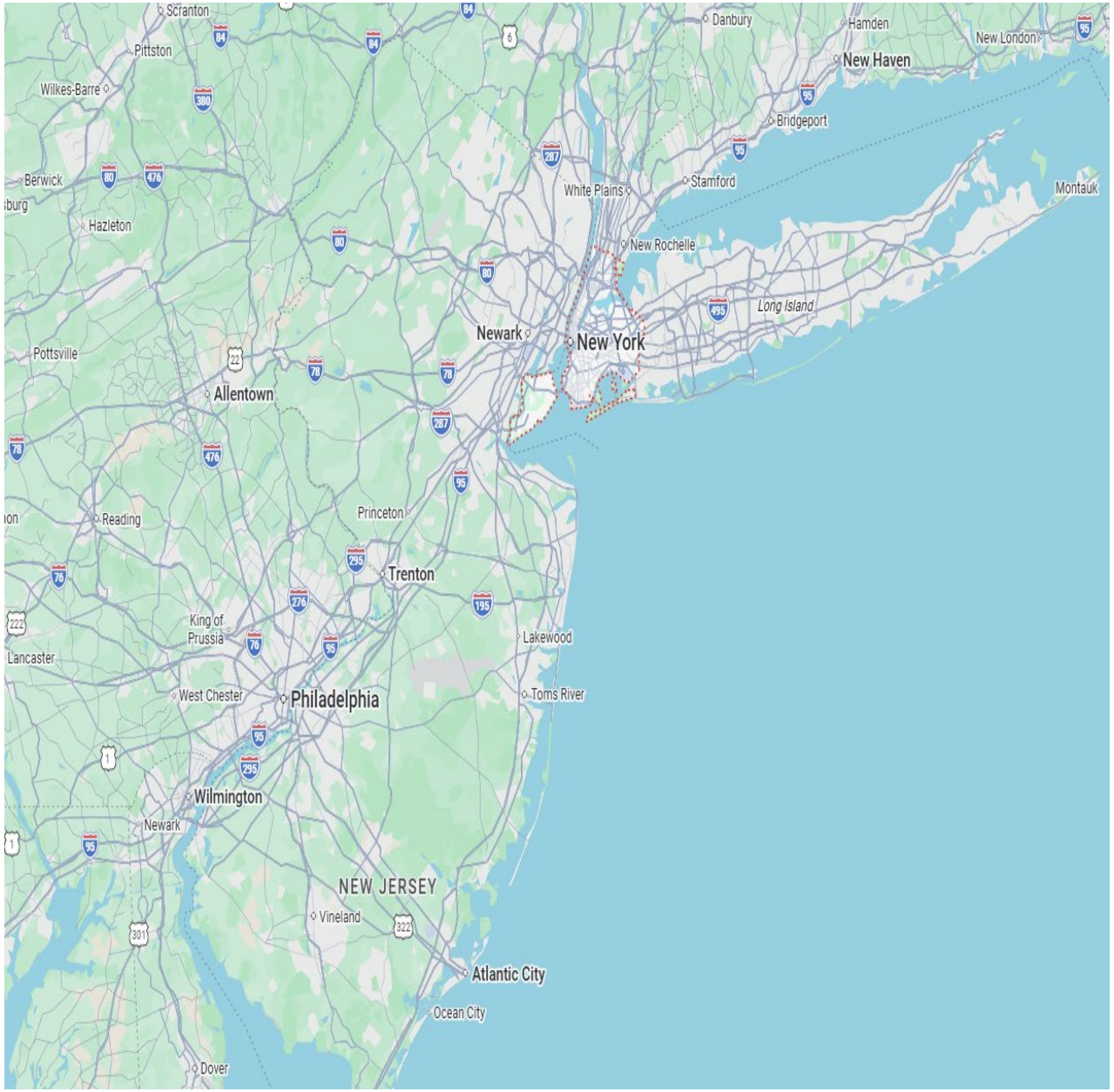


Source: Satellite-informed land-use regression estimates of surface-level NO_2 from Nawaz et al. (2025) in parts per billion. Spatial resolution is 0.01◦ × 0.01◦ (∼1 km × 1 km). Circles mark the CBDs of the New York and Philadelphia MSAs.

Note: World Health Organization recommended maximum annual average exposure is 5.3ppb

New York and Philadelphia NO_2 Air Pollution Map, 2019





New York Zip Codes with Highest NO_2 in 2019

ZIP	Name	NO_2 in 2019	NO_2 Change 2020-2019	NO_2 Change 2025-2019
10007	Tribeca / Civic Center	15.23	-1.63	-1.03
10038	Financial District / South Street Seaport	15.18	-1.61	-1.10
10271	Financial District (Equitable Building)	15.08	-1.65	-1.03
10279	Civic Center (Woolworth Building)	15.08	-1.65	-1.03
10006	Financial District / World Trade Center	14.97	-1.65	-1.03
10278	Civic Center (26 Federal Plaza)	14.94	-1.48	-1.08
10013	Tribeca / SoHo	14.92	-1.49	-0.98
11201	Downtown Brooklyn / Brooklyn Heights	14.90	-1.49	-1.22
10005	Financial District / Wall Street	14.62	-1.56	-1.03
10045	NY Federal Reserve Bank	14.62	-1.56	-1.03
10037	Harlem	14.50	-3.51	-1.21
10174	Midtown East / Chrysler Building	14.49	-2.42	-1.03
10170	Grand Central / Graybar Building	14.46	-2.41	-1.05
10165	Grand Central / Midtown East	14.46	-2.41	-1.05
10033	Washington Heights / Hudson Heights	14.37	-4.09	-1.47
10167	Grand Central / Midtown East	14.34	-2.43	-1.01
10017	Midtown East / Turtle Bay	14.27	-2.43	-1.01
10110	Midtown / Bryant Park	14.20	-2.41	-1.03
10012	NYU Economics Department	14.12	-1.53	-1.12
10027	Columbia Economics Department	13.11	-3.50	-1.16

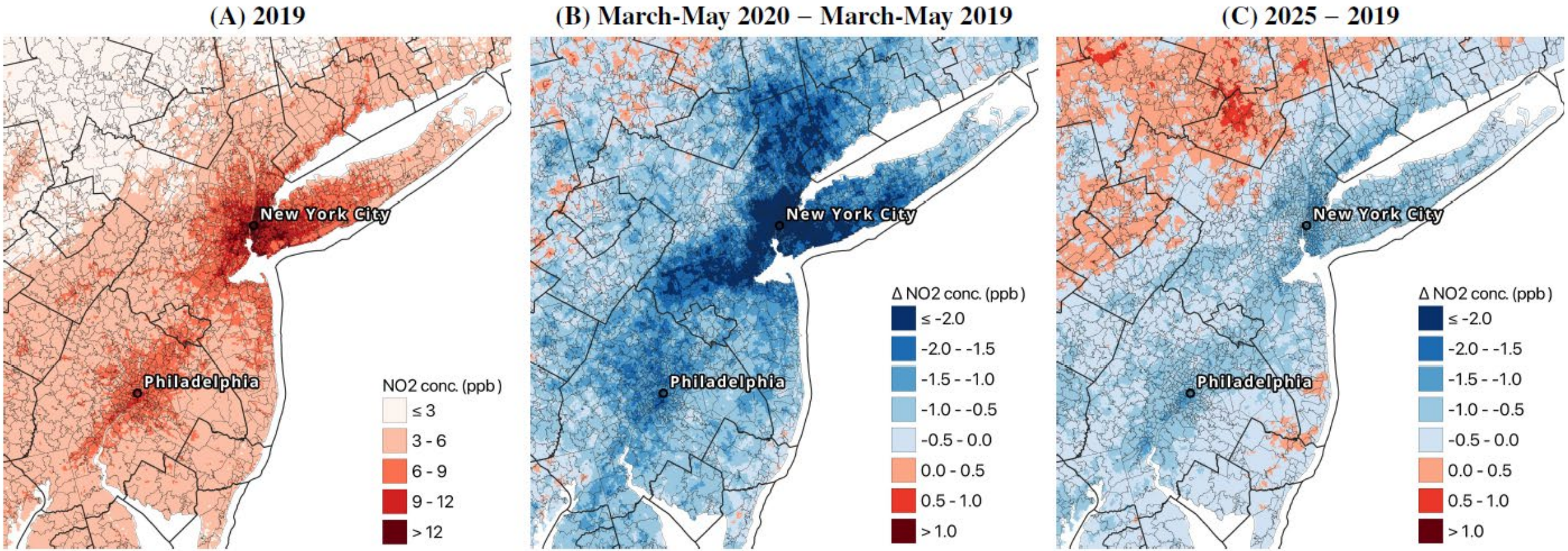
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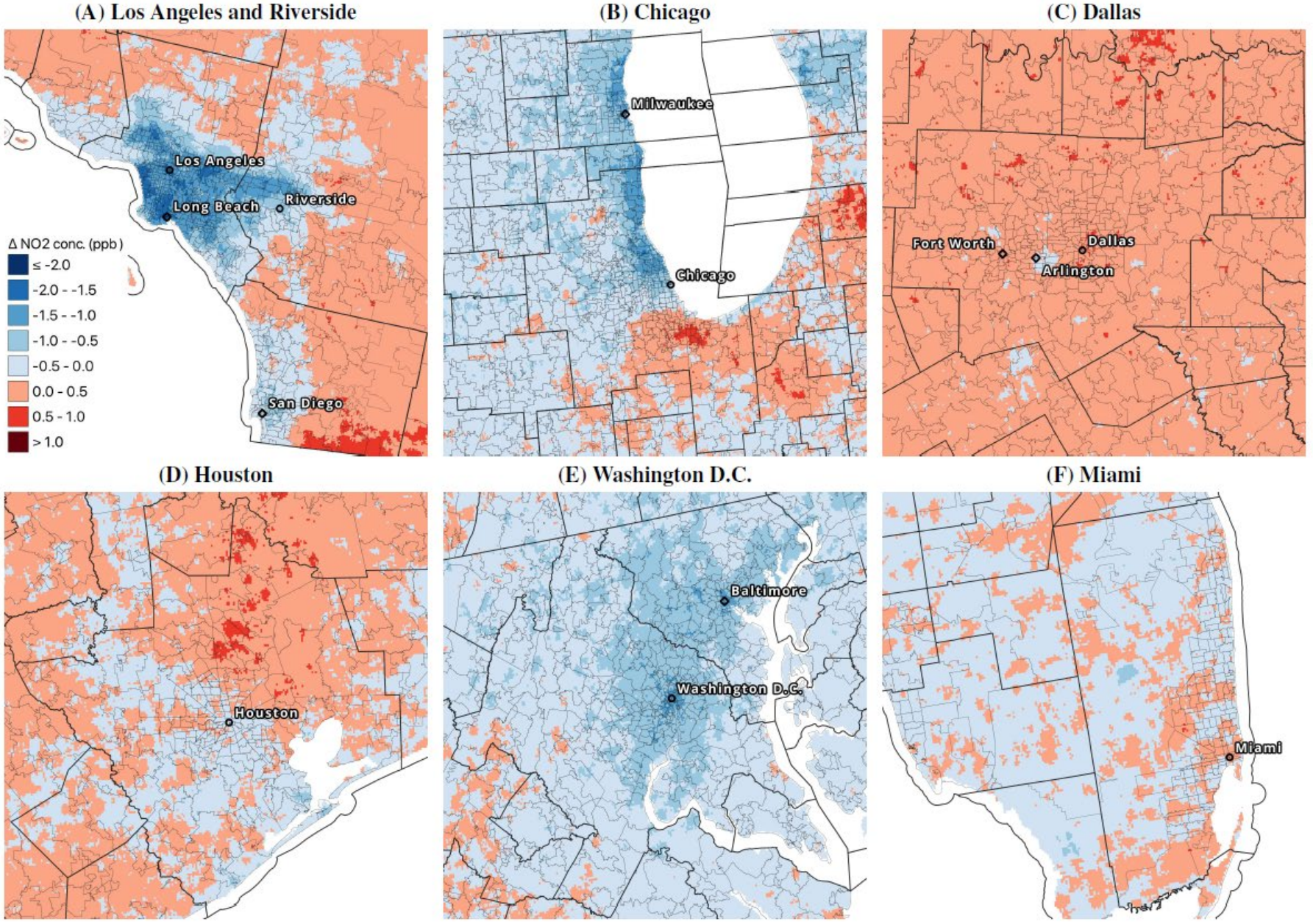
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New York NO_2 Air Pollution Map: 2019; 2020-2019; and 2025-2019



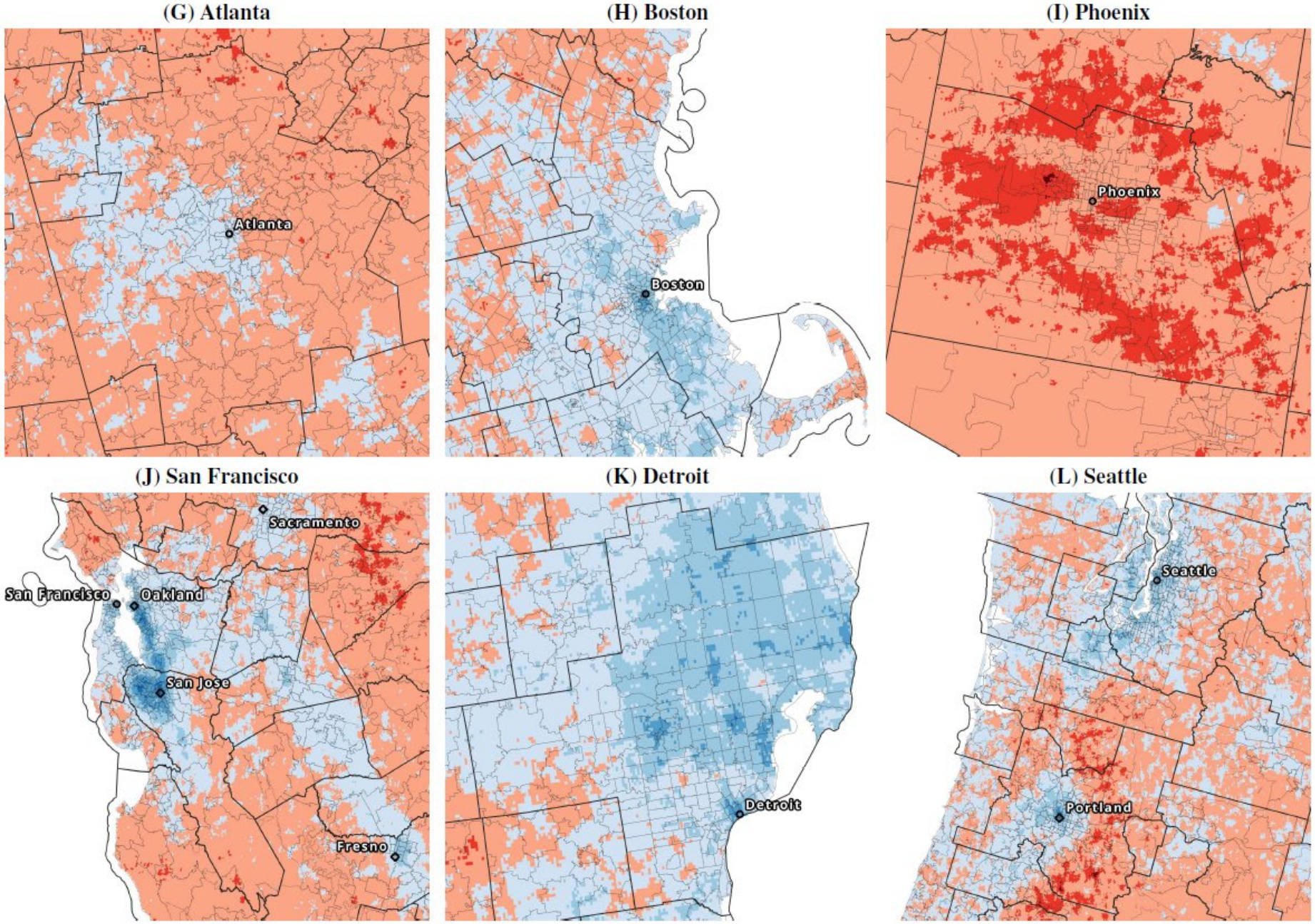
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Largest 15 US MSAs: Air Pollution Map change 2019 to 2025 (1/2)



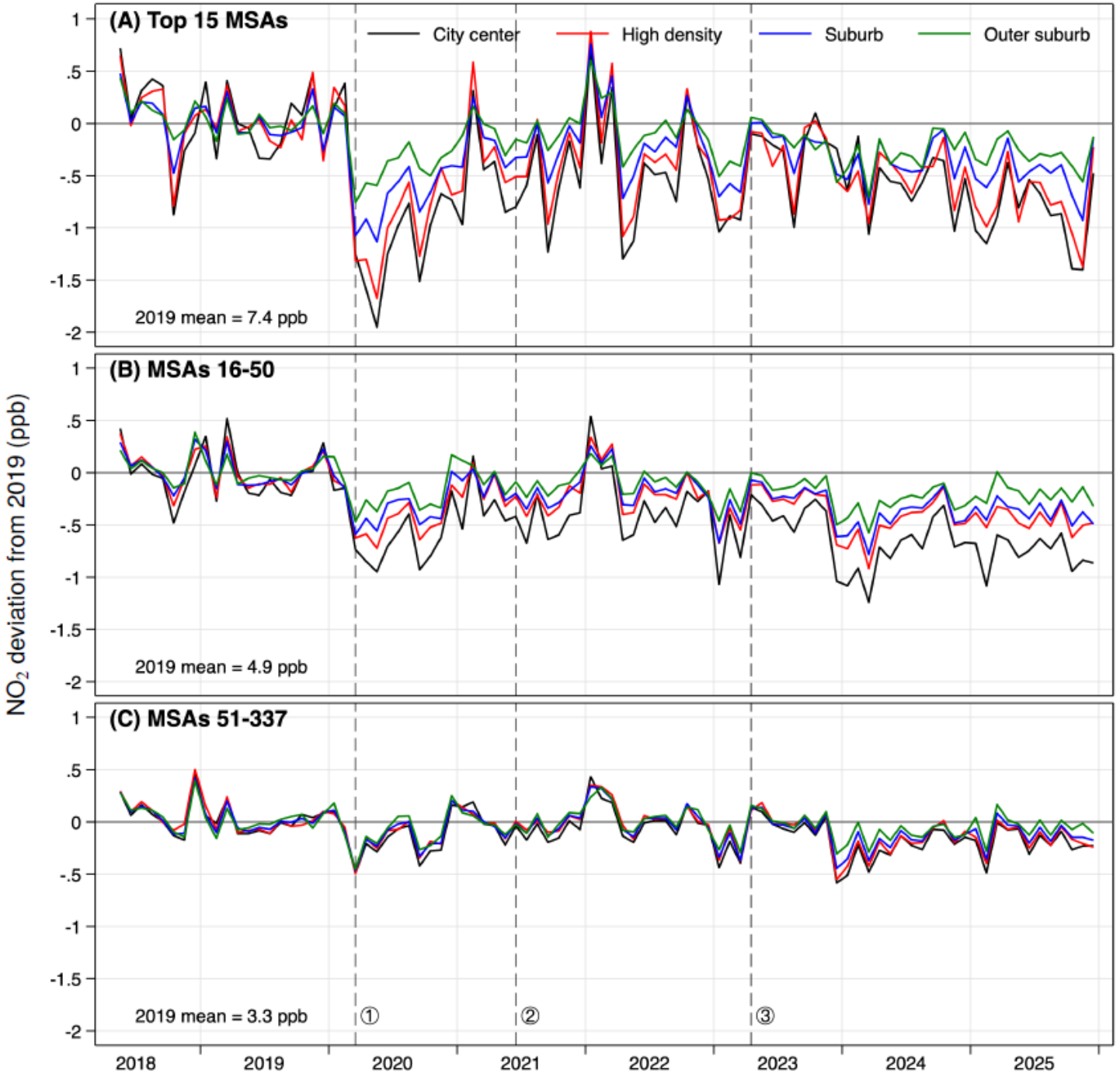
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Largest 15 US MSAs: Air Pollution Map change 2019 to 2025 (2/2)



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MSA NO_2 by month



Source: Deviations in parts per billion from each ZIP code's 2019 average, based on deseasoned ZIP-code-level NO_2 concentrations, averaged across ZIP codes within each MSA size and ZIP code density group and weighted by 2019 ZIP code population. Monthly data, May 2018 through December 2025.

Lines show city-center (within 2 miles of CBD), high-density (remaining top 10% density), suburb (50th to 90th deciles), and outer-suburb (below 50th decile density). Each panel reports the population-weighted average across all ZIP codes in that MSA size group.

Dashed vertical lines mark:
① Presidential national emergency (March 2020)
② Last statewide stay at home order (June 2021)
③ End of the national emergency (April 2023).

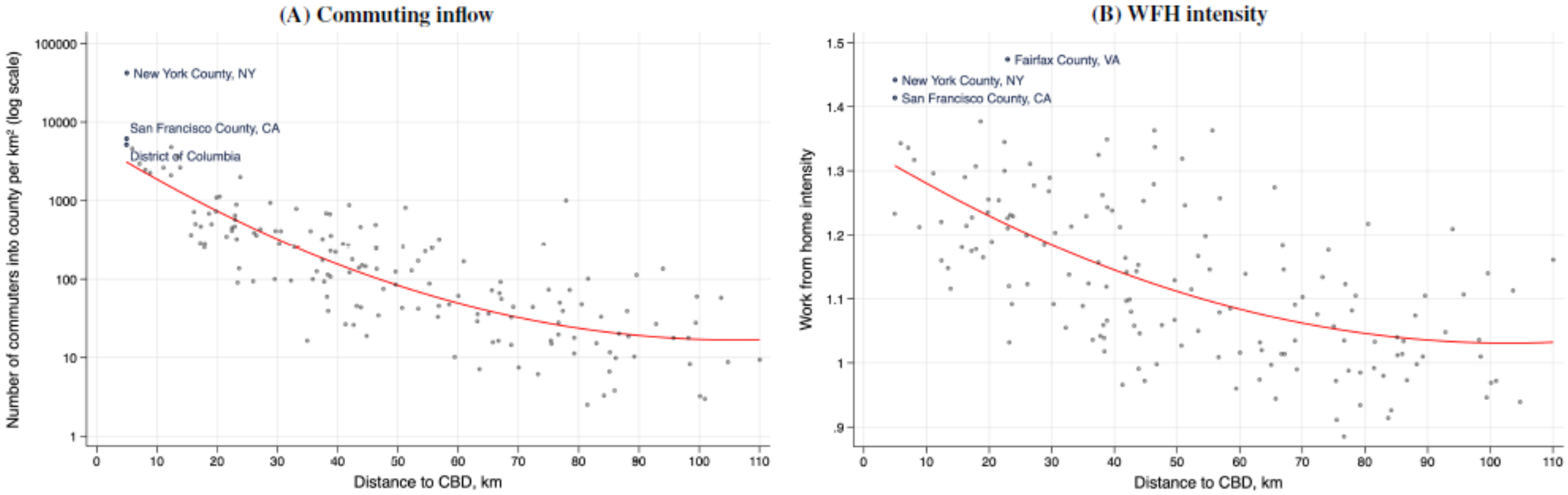
Data

Pollution

Connection to WFH

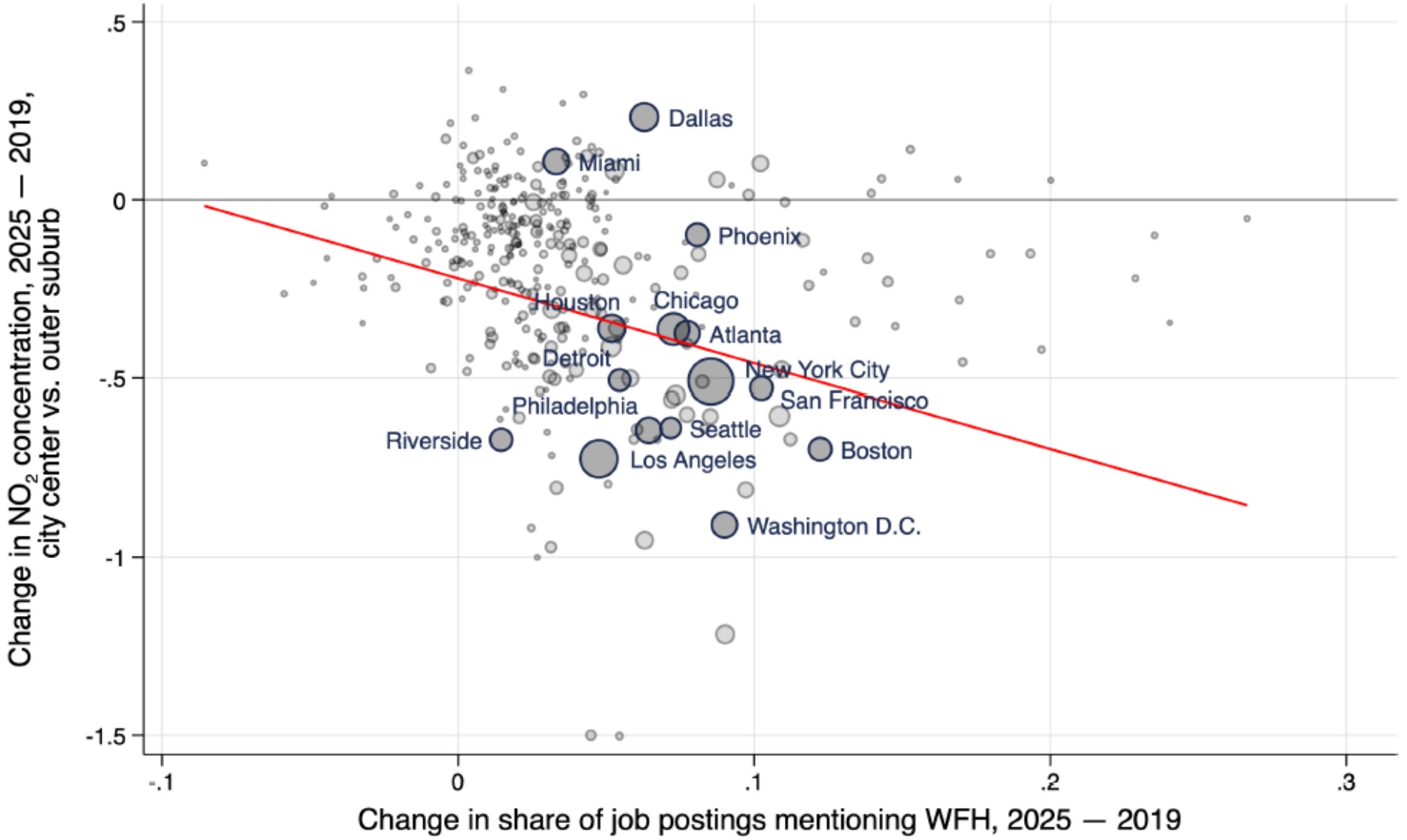
Predicted Mortality Effects

Commuting and WFH industries concentrated near city centers



Source: Each point represents one of the 155 counties within the 15 largest MSAs. The horizontal axis shows the population-weighted mean distance from the county's census tracts to its MSA's CBD, in kilometers. Selected counties are labeled. (A) Commuting inflow, measured as the number of workers commuting into the county, summed across all counties of residence, per km2 of county land area, on a log scale. Data are from the 2015-2019 ACS County-to-County Commuting Flows. The red line is a quadratic fit to log commuting inflow, shown in levels. (B) WFH intensity, measured as full-paid days worked from home, using ACS industry activity weights and industry WFH data from the U.S. Survey of Working Arrangements and Attitudes for March 2025 to February 2026. The red line is a quadratic fit.

MSAs with the largest center falls in NO_2 have the highest WFH rise



Source: Each dot is an MSA, plotting the change in NO2 concentration, 2025 − 2019, in city-center ZIP codes relative to outer-suburb ZIP codes (vertical axis) against the MSA-level change in the share of job postings mentioning WFH, 2025 − 2019 (horizontal axis). Postings data are from Hansen et al. (2023). County-level changes are aggregated to MSAs weighting by the number of postings. Counties with fewer than 250 postings across both years are excluded, leaving 333 MSAs. Dot sizes are proportional to 2019 MSA population, and the 15 largest MSAs are labeled. The red line is the population-weighted linear fit,

Other possible non-WFH stories?

- **Cleaner vehicles** and/or industrial pollution regulations - hard to explain sharp drop in 2020, greater fall in city centers, and cross-city correlations with WFH



- **Population shifts** out of city centers reduces city center heating pollution – similar summer/winter declines weigh against residential heating as main explanation



Log changes in 2019 to 2025 in NO2 by season

		City center	High density	Suburb	Outer suburb	All ZIP codes
Top 15 MSAs	Jun-Sep	-0.067	-0.068	-0.056	-0.054	-0.058
		(0.022)	(0.017)	(0.020)	(0.021)	(0.019)
	Oct-May	-0.092	-0.077	-0.060	-0.040	-0.057
		(0.012)	(0.018)	(0.018)	(0.020)	(0.018)
	Difference	0.025	0.009	0.004	-0.014	-0.000
		(0.026)	(0.025)	(0.027)	(0.023)	(0.026)

- **Drop in commercial traffic** in CBDs due to less office workers – still WFH impact



Data

Pollution

Connection to WFH

Predicted Mortality Effects

Translating Reductions in NO2 into Predicted Reduced Mortality

Use the US EPA framework from Sacks et al. (2018), Huangfu and Atkinson (2020)

$$\text{Annual deaths averted}_g = D_{0g}\left[1 - \exp\left(\theta\,\Delta NO_{2g}\right)\right], \quad \theta = \frac{1.88\ln(1.02)}{10} \approx 0.00372 \text{ per ppb}$$

Deaths_0	Baseline annual deaths in group g, calculated from 2019 population and 2015–2019 county mortality rates
ΔNO_2	Estimated 2025 minus 2019 concentration change, in ppb; negative for a decline.
G	Relevant MSA-size/density group.

Estimated by 16,383 zip codes, weighted up by population. Generate range by applying lower and upper bounds of the 95% confidence interval around NO_2 change.

Predicted changes in NO_2 and reductions in mortality

		City center	High density	Suburb	Outer suburb	All ZIP codes
Top 15 MSAs	Population	2.2 M	16.4 M	55.6 M	33.2 M	107.4 M
	2019 average NO_2	10.95	10.00	7.67	5.31	7.36
	Δ NO_2 (SE)	-0.87	-0.76	-0.48	-0.30	-0.47
		(0.10)	(0.16)	(0.13)	(0.13)	(0.13)
	Averted deaths	[40; 60]	[180; 450]	[310; 1,060]	[50; 500]	[600; 2,080]
MSAs 16-50	Population	2.1 M	8.7 M	38.5 M	18.7 M	68.0 M
	2019 average NO_2	7.76	6.13	5.07	3.50	4.86
	Δ NO_2 (SE)	-0.76	-0.45	-0.38	-0.20	-0.35
		(0.14)	(0.10)	(0.09)	(0.07)	(0.09)
	Averted deaths	[30; 60]	[70; 170]	[220; 630]	[40; 200]	[370; 1,060]
MSAs 51-337	Population	8.5 M	11.8 M	47.1 M	19.3 M	86.8 M
	2019 average NO_2	4.12	3.89	3.32	2.70	3.33
	Δ NO_2 (SE)	-0.19	-0.16	-0.11	-0.04	-0.11
		(0.03)	(0.03)	(0.02)	(0.02)	(0.02)
	Averted deaths	[40; 70]	[40; 90]	[100; 250]	[0; 60]	[190; 460]
All MSAs	Population	12.8 M	36.9 M	141.3 M	71.2 M	262.2 M
	2019 average NO_2	5.89	7.13	5.51	4.13	5.38
	Δ NO_2 (SE)	-0.40	-0.49	-0.33	-0.20	-0.32
		(0.05)	(0.10)	(0.07)	(0.07)	(0.07)
	Averted deaths	[120; 200]	[310; 740]	[830; 1,890]	[160; 730]	[1,480; 3,540]

Notes: Total 2019 population in millions, the 2019 average NO2 concentration, the estimated change in NO2 concentration in 2025 relative to 2019, all in parts per billion (with standard errors in parentheses), and the implied range of averted annual deaths, for three MSA size and four ZIP code density groups. NO2 reduction estimates come from regressions of ZIP-code-level NO2 on a 2025 indicator, with ZIP code fixed effects, weighted by 2019 ZIP code population and with standard errors clustered by MSA. The averted-deaths range is computed by applying the concentration-response function of Huangfu and Atkinson (2020) to the upper and lower bounds of the 95 percent confidence interval on the NO2 coefficient, combined with each ZIP code's 2019 population and the 2015-2019 average county-level all-cause mortality rate. Averted deaths are rounded to the nearest ten.

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MSAs 51-337	Population	8.5 M	11.8 M	47.1 M	19.3 M	86.8 M
	2019 average NO_2	4.12	3.89	3.32	2.70	3.33
	Δ NO_2 (SE)	-0.19	-0.16	-0.11	-0.04	-0.11
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Conclusion

The post-pandemic NO_2 pollution in large US city centers is down by 8%

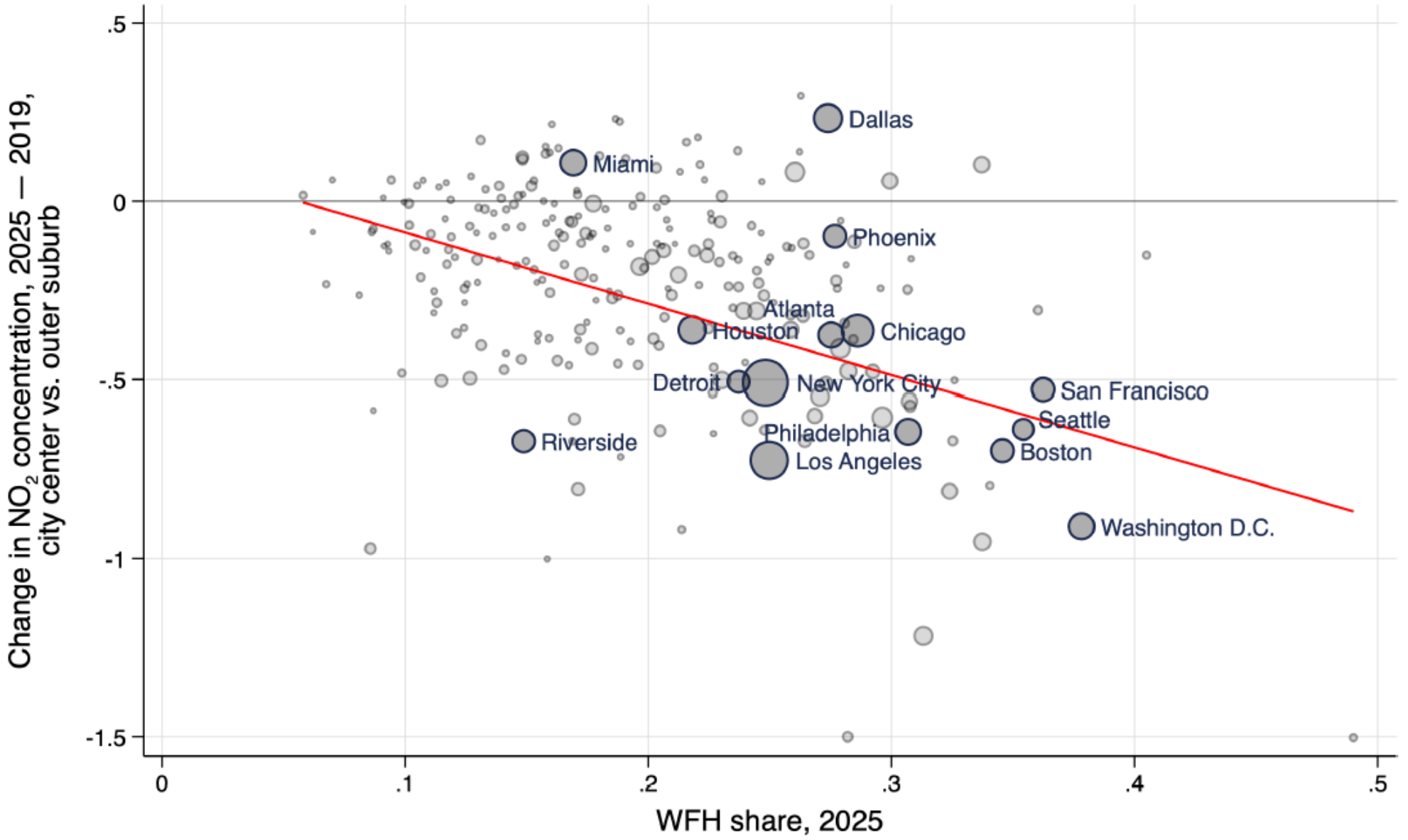
It appears WFH is a key driver of this by reducing commuting traffic

Estimate this could have reduced yearly US mortality by around 1,500 to 3,500

Highlights the wider health benefit from WFH (particularly for kids and the elderly)

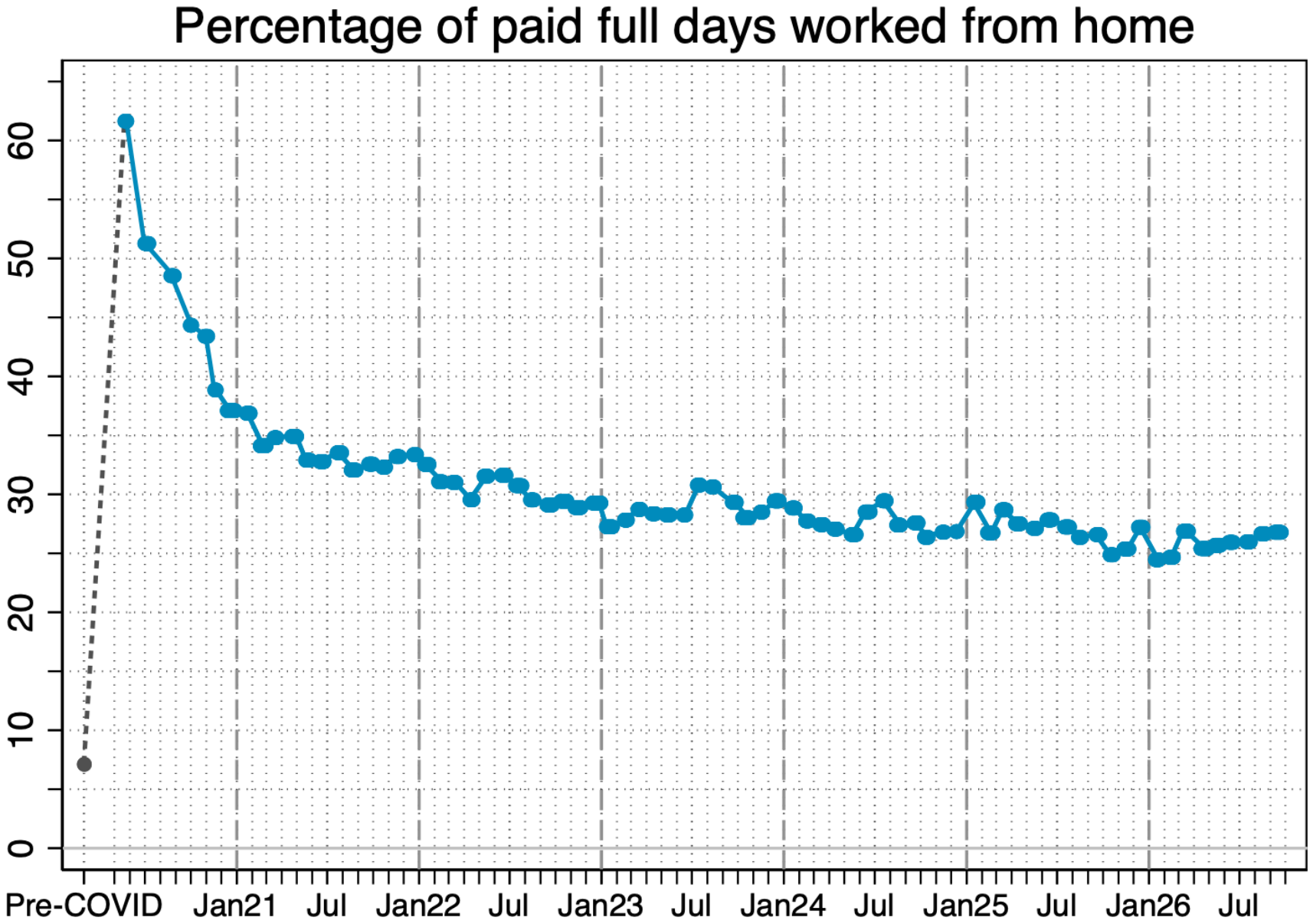
Back Up

MSAs with the largest center falls in NO_2 have highest 2025 WFH



Source: Each dot represents an MSA change in NO2 concentration, 2025 − 2019, in city-center ZIP codes relative to outer-suburb ZIP codes (vertical axis) against the MSA's 2025 WFH share, the share of employed individuals who did any paid work from home measured in the Current Population Survey (CPS) July 2024 to June 2026 (horizontal axis). Dot sizes proportional to 2019 MSA population. 15 largest MSAs are labeled. The red line is the population-weighted linear fit. MSAs with fewer than 100 CPS observations are excluded, leaving 250 MSAs.

Question: Did Improved Air Quality Persist (given Persistent WFH)?



Source: 271,229 (SWAA) N = 923,587 (HHP). SWAA data from survey responses weighted to match the US population. Pre-covid data from the American Time Use Survey. CHPS respondents weighted to match the US population aged 20 to 64 in households with incomes above $25,000.

Survey of Workplace Attitudes and Arrangements (Barrero, Bloom and Davis 2025)
https://wfhresearch.com/