Yale SCHOOL OF PUBLIC HEALTH
Center on Climate Change and Health

CHEN Lab
Climate, Health, and Environment Nexus

Short-term Air Pollution Exposure and Mental Health

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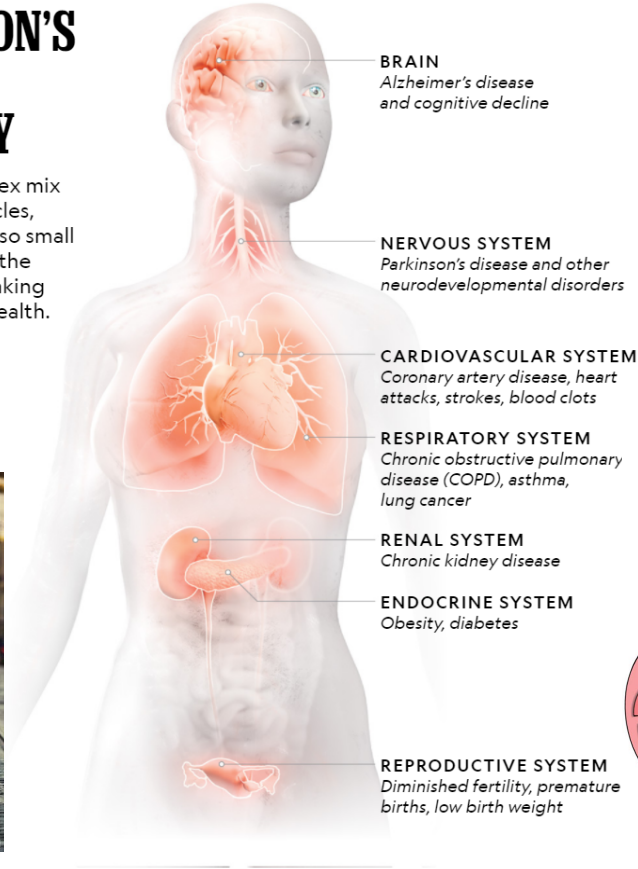
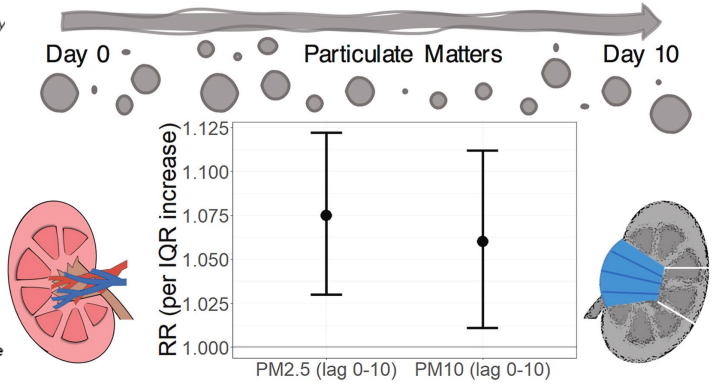
Health effects of air pollution

POLLUTION'S TOLL ON THE BODY

Dirty air is a complex mix of gases and particles, some of which are so small they can pass into the bloodstream, wreaking havoc on human health.

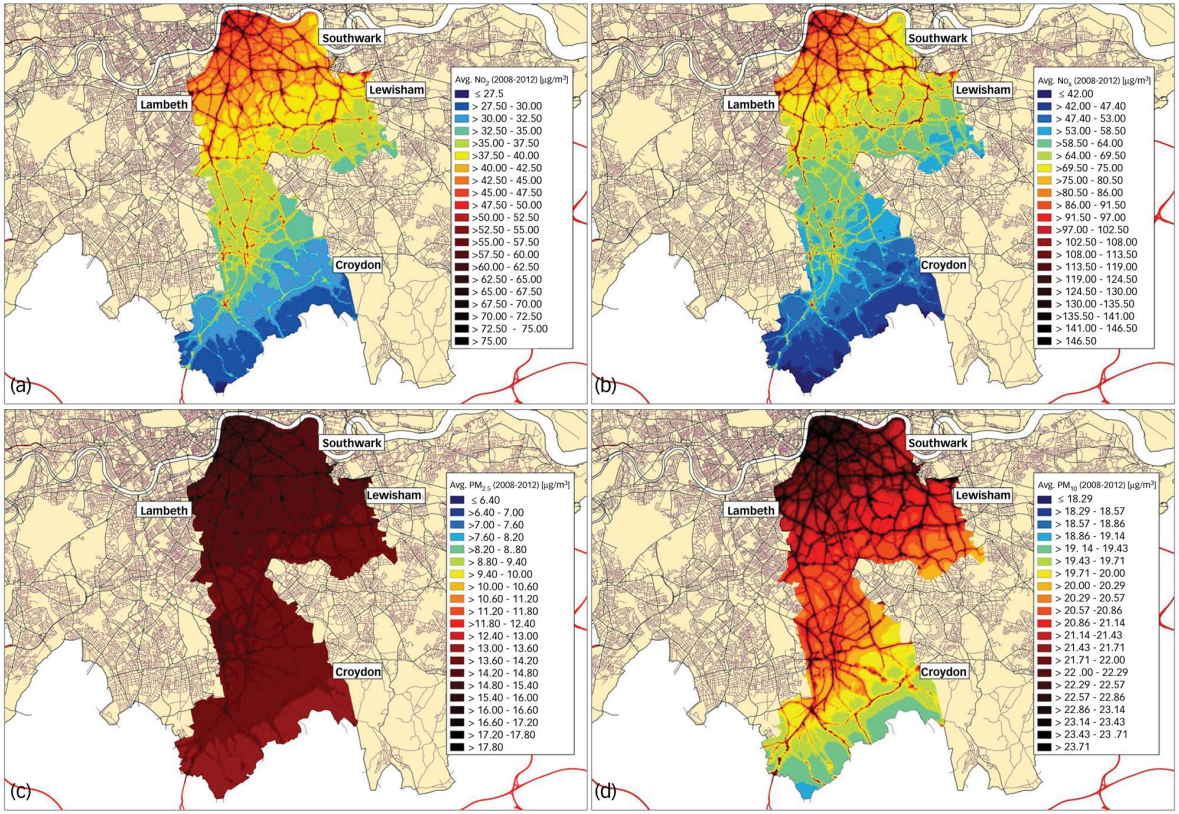
NATIONAL GEOGRAPHIC





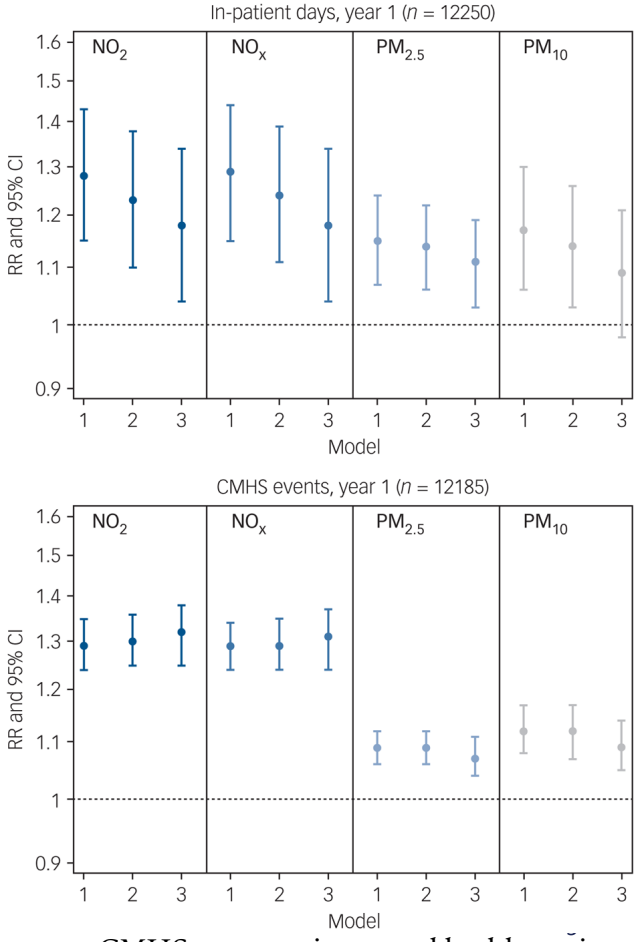
- **Chen**, et al. *Environ Health Perspect*, 2020; *Lancet Planetary Health*, 2021; **Chu**, et al. *Environ Pollut*, 2021; **Wang,** et al. *Environ Pollut*, 2020.

Long-term air pollution exposure and mental health service use among people recently diagnosed with psychotic and mood disorders.



South London

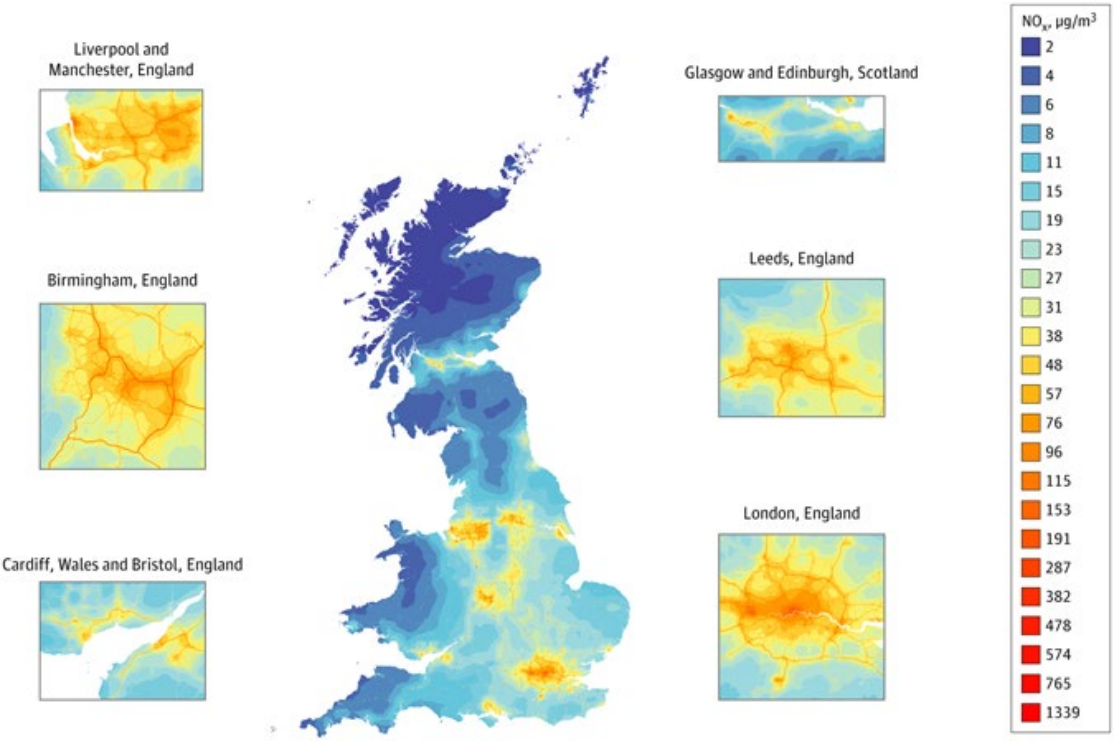
- Newbury et al. *Br J Psychiatry*. 2021



CMHS, community mental health services

Air pollution in childhood and adolescence associated with the development of psychopathology at the transition to adulthood

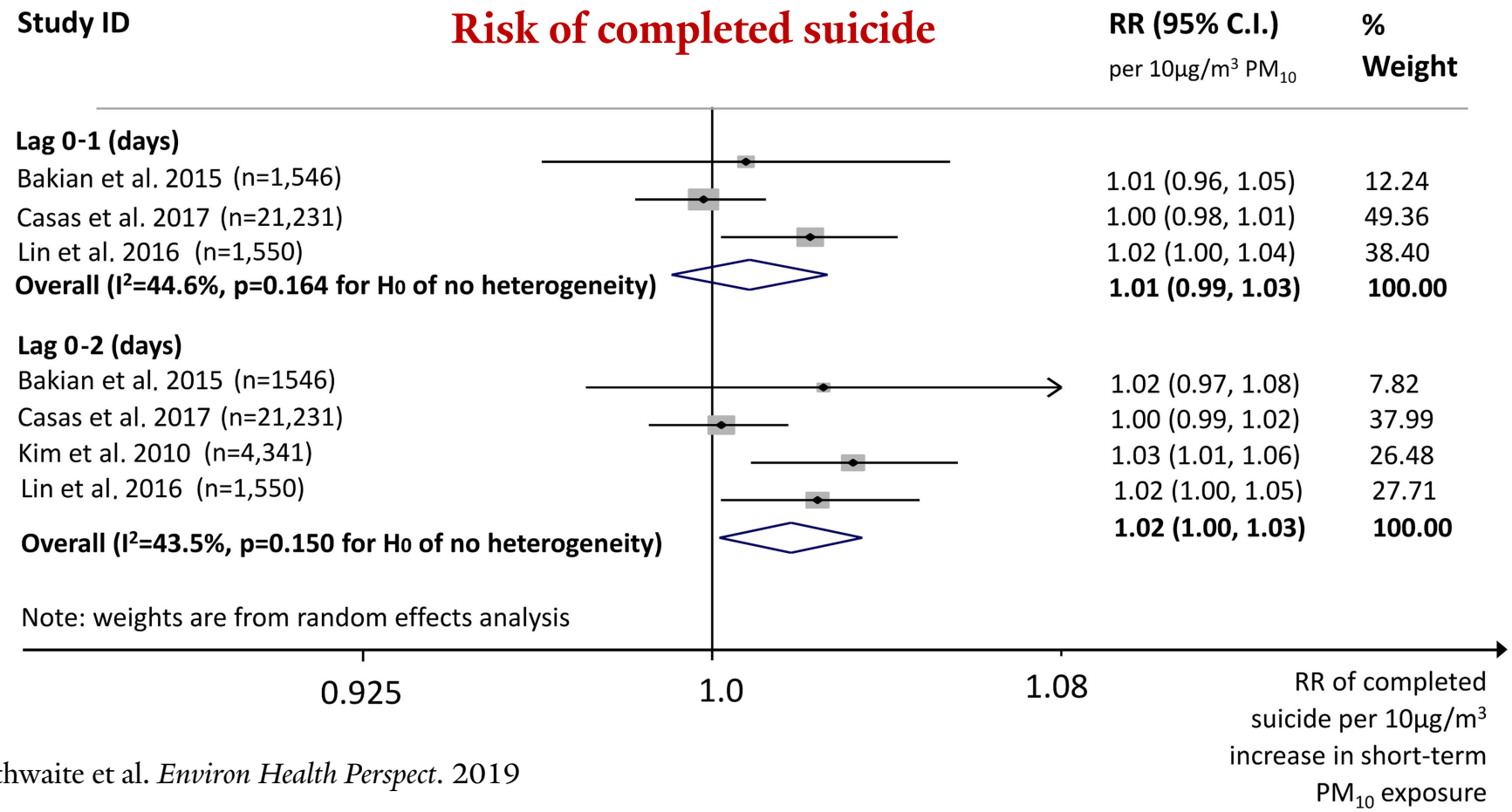
Mean Annual NOx averaged across 2004-2012



	Air pollution exposure measured continuously and scaled to the interquartile range			
	NO_x		$PM_{2.5}$	
Disorder	b (95% CI)	*P* value	b (95% CI)	*P* value
General psychopathology	1.40 (0.41 to 2.38)	.005	0.45 (−0.26 to 1.15)	.22
Internalizing	1.07 (0.10 to 2.04)	.03	0.25 (−0.47 to 0.96)	.50
Externalizing	1.42 (0.53 to 2.31)	.002	0.64 (0.02 to 1.26)	.04
Thought disorder	1.54 (0.50 to 2.57)	.004	0.51 (−0.23 to 1.24)	.18

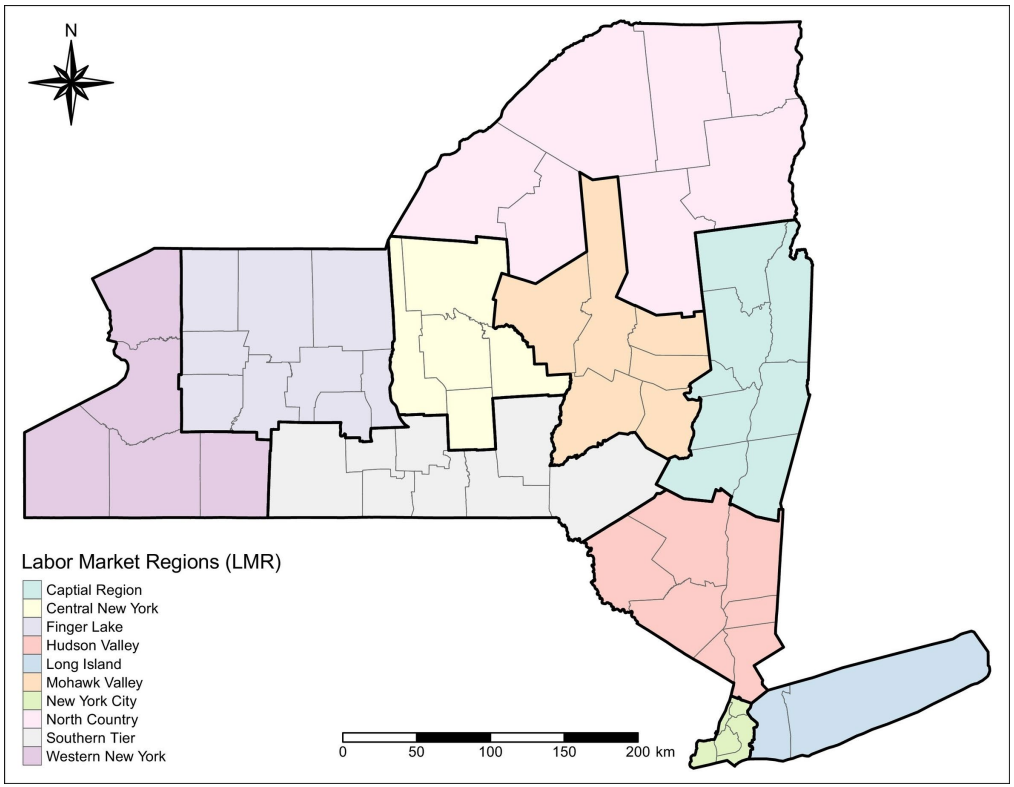
- Reuben et al. *JAMA Network Open*. 2021

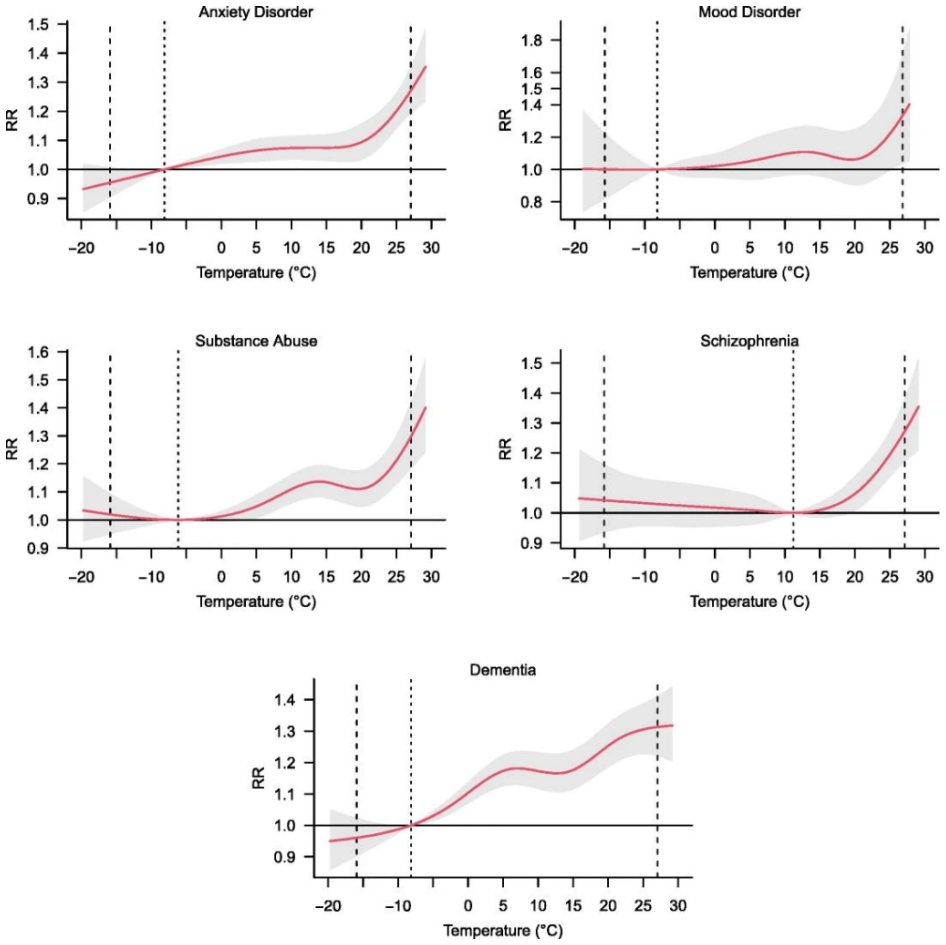
Less is known about how short-term air pollution impacts the utilization of general mental health services



- Braithwaite et al. *Environ Health Perspect*. 2019

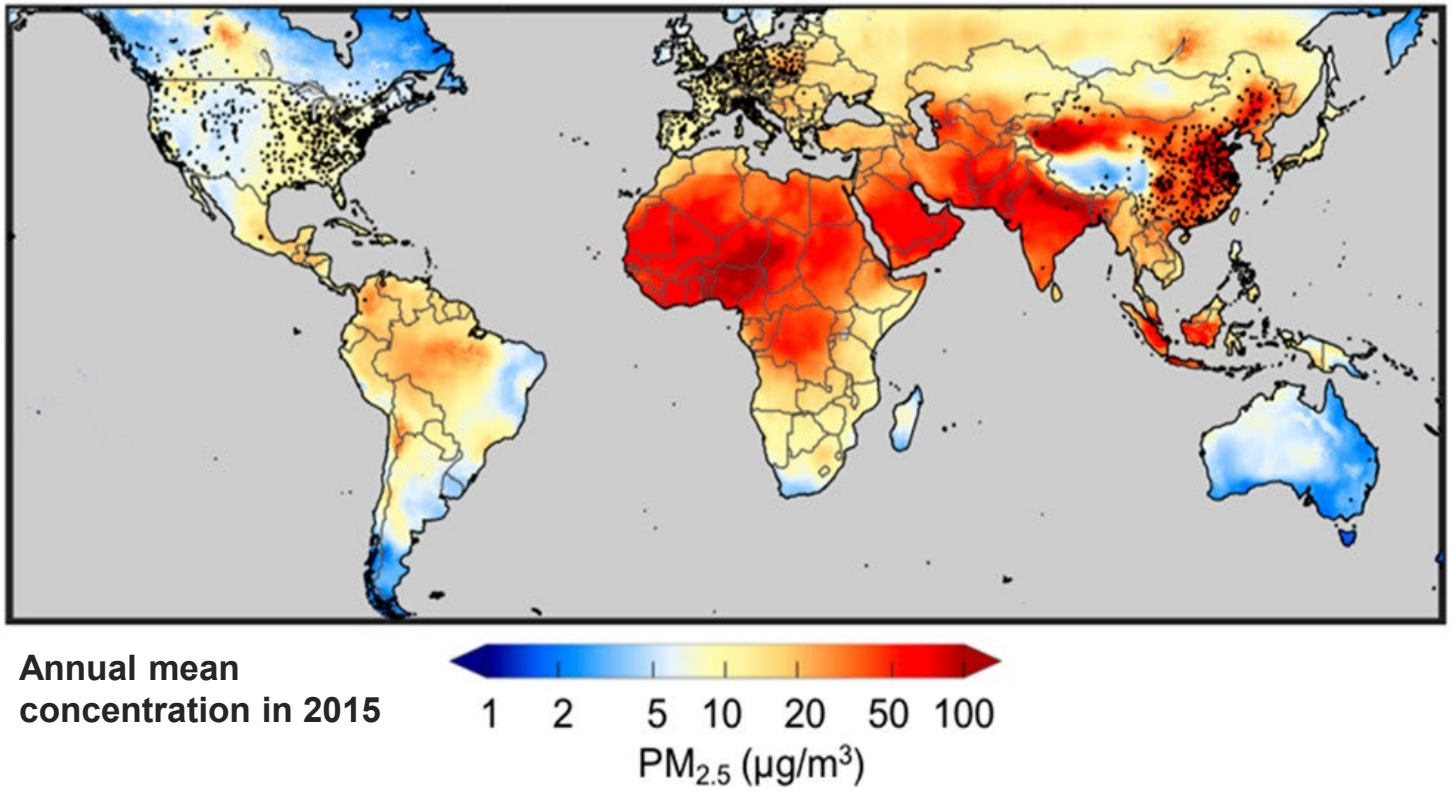
Our recent analysis shows that short-term heat exposure increased ER visits related to mental disorders





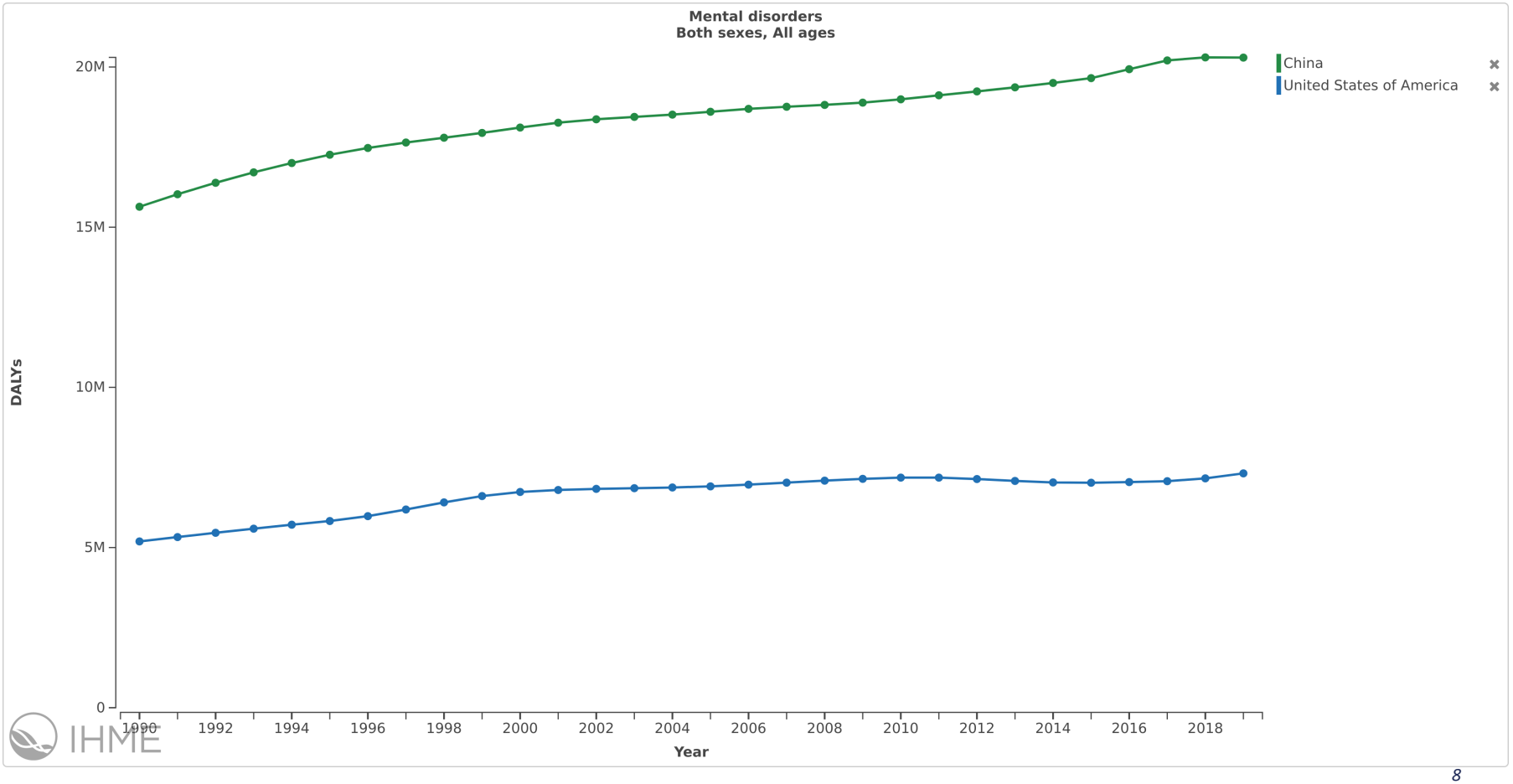
- **Yoo** et al. *Sci Total Environ*. 2021

China is among the highest level of outdoor air pollution



- Hammer et al, *Environ. Sci. Technol*, 2020

The prevalence of most mental disorders has also been increasing in the past 30 years in China



Study 1: Daily particulate matter air pollution and mental health outpatient visits in Nanjing, China

Contents lists available at ScienceDirect

Environmental Research

journal homepage: www.elsevier.com/locate/envres

Particulate matter pollution and risk of outpatient visits for psychological diseases in Nanjing, China

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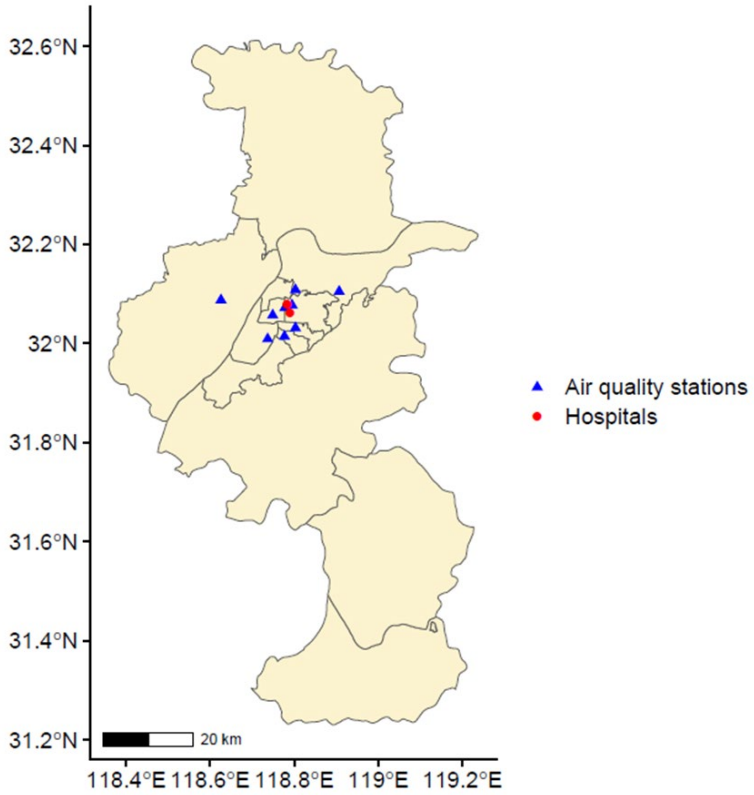
ABSTRACT

Exposure to air pollution has been associated with increased risk for a range of adverse mental health conditions. Less is known about whether air pollution is also associated with increases in the utilization of mental health services, especially outpatient mental health service utilization. This study aimed to examine the association between the number of daily outpatient visits at the psychological disease departments of two major hospitals (PSYC) and daily average concentrations of $PM_{2.5}$ and PM_{10} in a heavily polluted city in China, Nanjing, from 2013/7/1 to 2019/2/28, using generalized additive models with a quasi-Poisson regression. Results showed that each 10 μg/m^3 increase in $PM_{2.5}$ concentration on lag0 day was associated with a 0.40% increase (95% CI: 0.07-0.72) in PSYC visits, and each 10 μg/m^3 increase in PM_{10} concentration on the same day a 0.31% increase (95% CI: 0.09-0.54) in PSYC visits. Exposure-response curves suggested linear relationships between PM concentration and daily PSYC outpatient visits, without evidence of a threshold. Associations remained positive, but were non-significant, with adjustment for co-pollutants, SO_2, NO_2 and CO. Significantly larger effects were found for older and male participants, vs. their counterparts. These findings add to the growing literature linking air pollution to



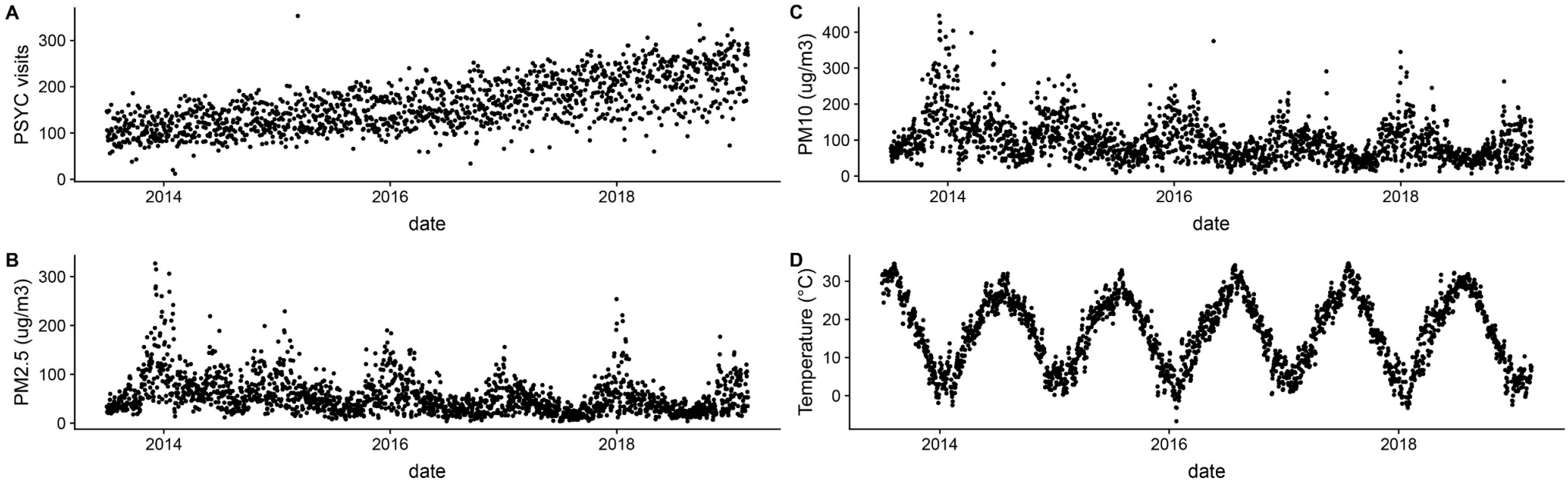
- **Lowe** et al, *Environ Res,* 2020.

Heavy air pollution in Nanjing City

July 1st, 2013 to Feb. 28th, 2019	Mean ± SD
PSYC (visits)	
Total	160.7 ± 54.2
5–64 years	130.0 ± 50.0
65+ years	27.1 ± 9.7
Male	65.1 ± 22.1
Female	92.8 ± 36.8
Warm season	159.9 ± 52.3
Cold season	161.4 ± 56.1
Air pollutants	
$PM_{2.5}$ (μg/m^3)	54.9 ± 39.3
PM_{10} (μg/m^3)	96.7 ± 58.6
SO_2 (μg/m^3)	18.6 ± 12.1
NO_2 (μg/m^3)	48.1 ± 20.3
CO (mg/m^3)	0.9 ± 0.4
Meteorological factors	
Temperature (°C)	16.7 ± 9.3
RH (%)	72.8 ± 13.8

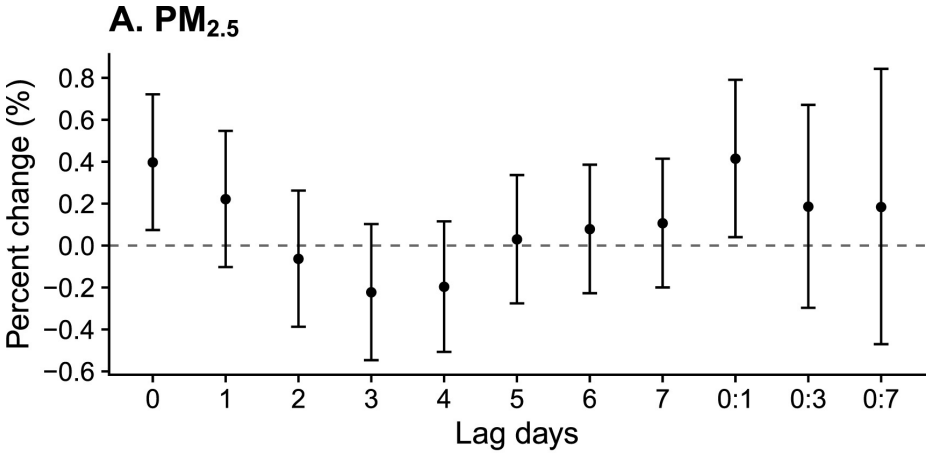
A time-series approach to evaluate the association between short-term air pollution exposure and health

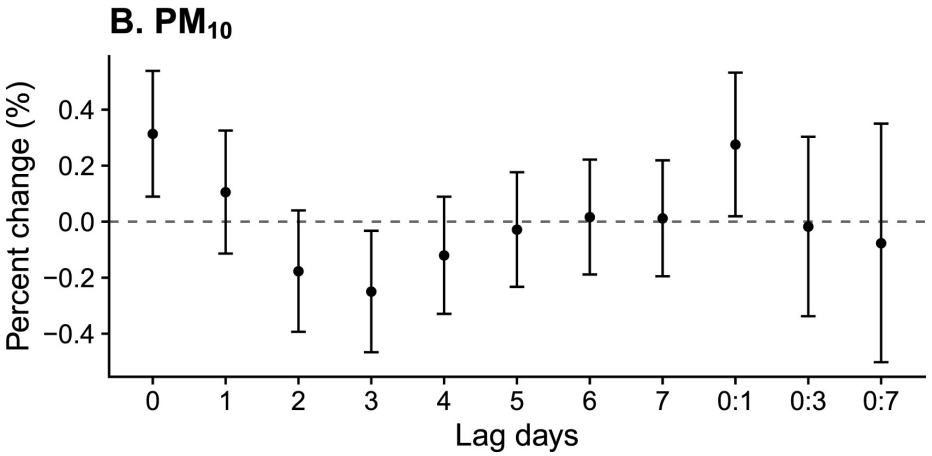
- **We applied a generalized additive model with a quasi-Poisson regression to evaluate the association between PM concentrations and PSYC outpatient visits, while controlling confounding by underlying time trends, temperature, relative humidity, and the day of week effect.**

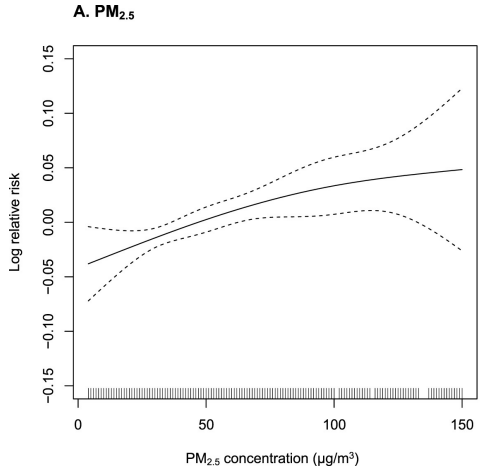


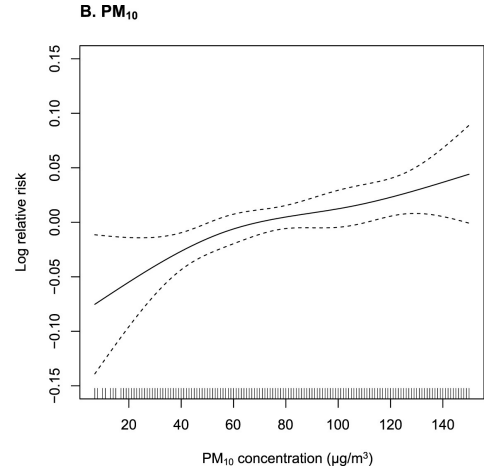
- **Lowe** et al, *Environ Res,* 2020.

Acute, linear effects for short-term PM exposure on PSYC









Effect modification by age, sex, and season

Potential effect modification by season, sex, and age groups on the association of outpatient visits for psychological diseases (PSYC) with $PM_{2.5}$ and PM_{10}.

PM	Potential effect modifier	Percent change (95% CI)	*p* value[a]
$PM_{2.5}$	*Age*		
	5–64	0.10 (−0.18, 0.39)	<0.001
	65+	1.75 (1.26, 2.25)	
	Sex		
	Male	0.80 (0.45, 1.14)	0.001
	Female	0.12 (−0.19, 0.43)	
	Season		
	Warm	0.33 (−0.39, 1.06)	0.821
	Cold	0.42 (0.07, 0.78)	
PM_{10}	*Age*		
	5–64	0.10 (−0.10, 0.30)	<0.001
	65+	1.27 (0.94, 1.61)	
	Sex		
	Male	0.61 (0.37, 0.85)	<0.001
	Female	0.10 (−0.11, 0.31)	
	Season		
	Warm	0.05 (−0.37, 0.48)	0.155
	Cold	0.40 (0.15, 0.65)	

But PM moderate to high correlations with other pollutants

Table S1. Spearman correlation coefficients between concentrations of air pollutants and meteorological variables in Nanjing from July 1, 2013 to February 28, 2019.

	$PM_{2.5}$	PM_{10}	SO_2	NO_2	CO	O_3	Temperature	RH
$PM_{2.5}$	1							
PM_{10}	0.92	1						
SO_2	0.58	0.71	1					
NO_2	0.68	0.74	0.64	1				
CO	0.66	0.62	0.56	0.59	1			
O_3	-0.13	-0.04	0.03	-0.18	-0.14	1		
Temperature	-0.36	-0.32	-0.17	-0.41	-0.26	0.55	1	
RH	-0.17	-0.41	-0.57	-0.32	-0.1	-0.32	0.12	1

Two-pollutant model shows decreased risk estimates, calling for future study on air pollution mixture

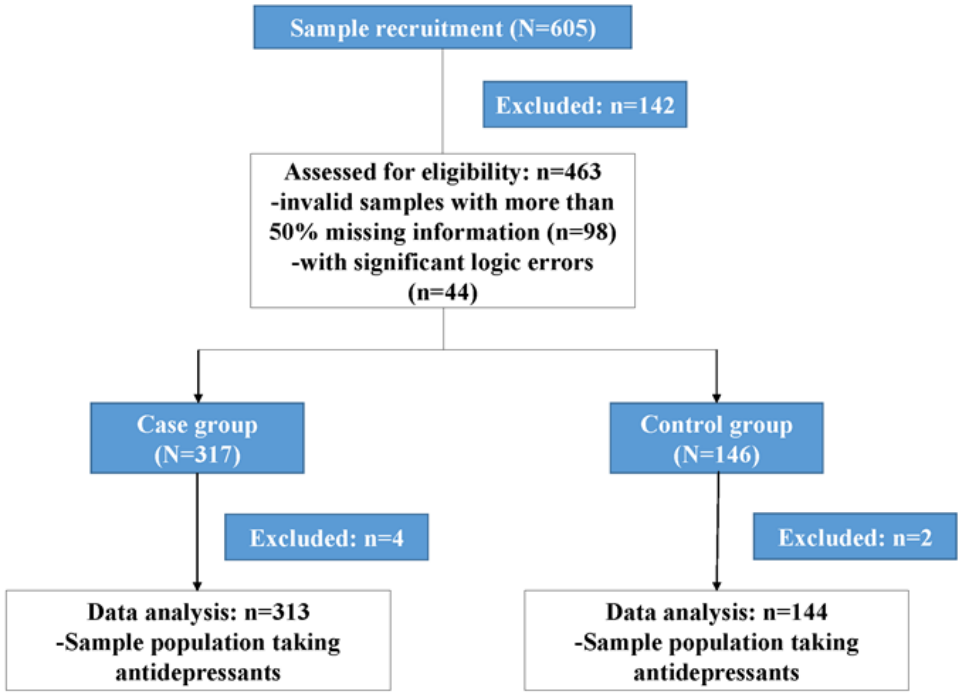
Percent changes (%) and 95% confidence intervals (CI) of outpatient visits for psychological diseases (PSYC) for a 10 μg/m^3 increase in $PM_{2.5}$ and PM_{10}, with and without adjustment for co-pollutants.

PM	Co-pollutant	Percent change (95% CI)	*p* value[a]
$PM_{2.5}$	–	0.40 (0.07, 0.72)	–
	+SO_2	0.28 (−0.11, 0.67)	0.645
	+NO_2	0.22 (−0.19, 0.63)	0.497
	+CO	0.26 (−0.21, 0.72)	0.628
PM_{10}	–	0.31 (0.09, 0.54)	–
	+CO	0.25 (−0.06, 0.56)	0.747

[a] Significance test of the difference in estimated changes between models with and without adjustment for co-pollutants.

- **Lowe** et al, *Environ Res,* 2020.

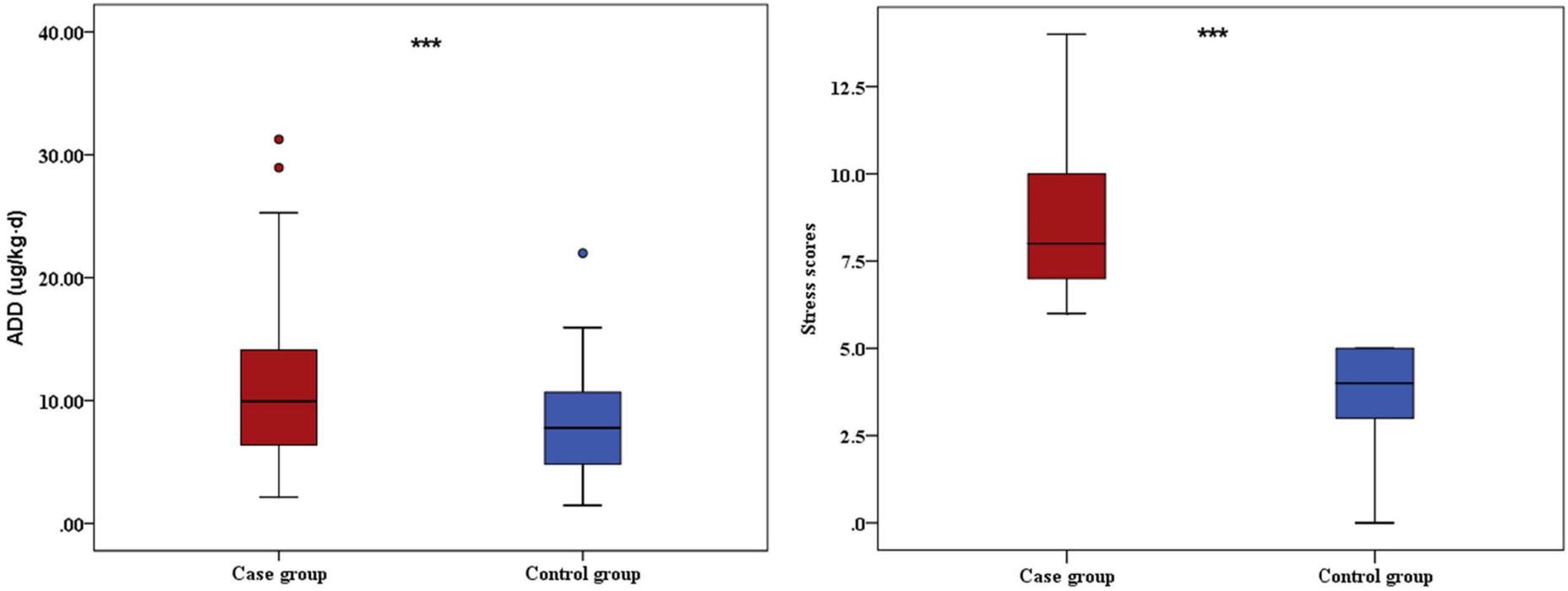
Study 2: Daily PM2.5 exposure and the mental stress of pregnant women in Nanjing, China



- Pregnant women 20–44 years old in the second trimester (22–24 weeks) were recruited from the Nanjing Maternal and Child Health Care Hospital during January 2018 - December 2018.
- Participants taking antidepressants (N = 6) were excluded.
- Face-to-face interview questionnaire on risk perception, mental stress, **time-activities**, individual characteristics.
- **Phobic anxiety scale scores** using the **Crown-Crisp Experiment Index**:
  - Case group (score of 6 or higher)
  - Control group (score of 5 or lower)

- **Li**, et al. *Environ Int*, 2021.

PM2.5 exposure of the case group was significantly higher compared with the control group



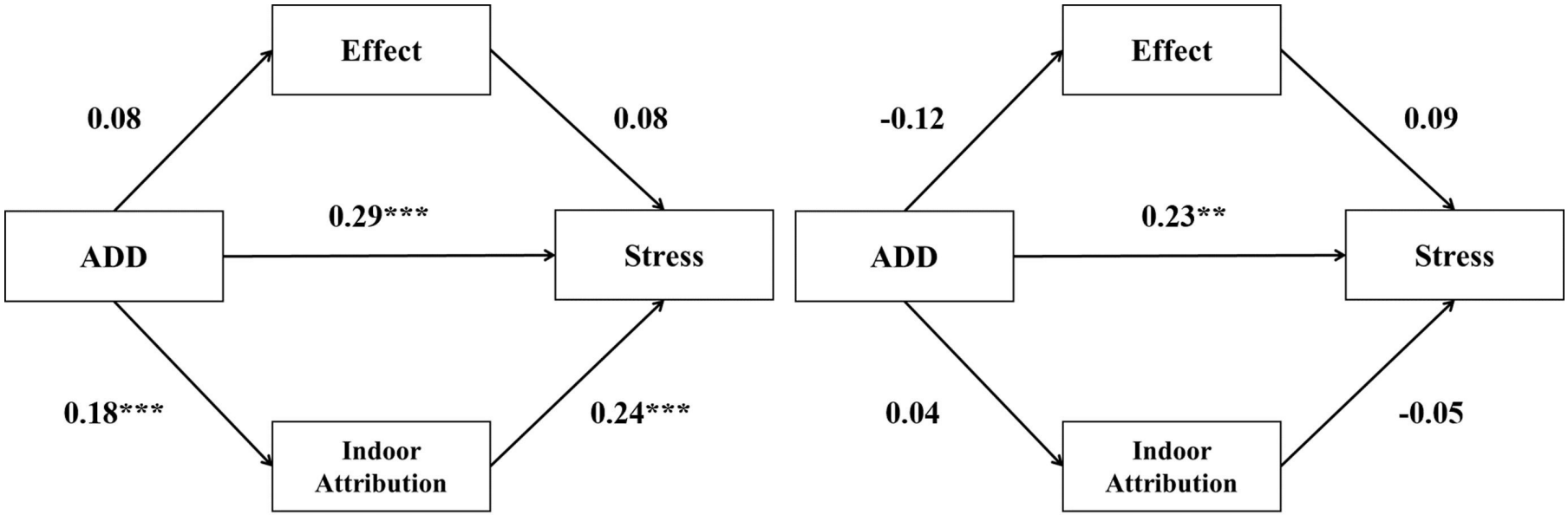
$$\mathrm{ADD} = (C \times IR_1 \times EF_1/24 + C \times R \times IR_2 \times EF_2/24)/BW$$

where ADD is the daily dose of $PM_{2.5}$ prior to the interview ($\mu g/kg \cdot d$);

- **Li**, et al. *Environ Int*, 2021.

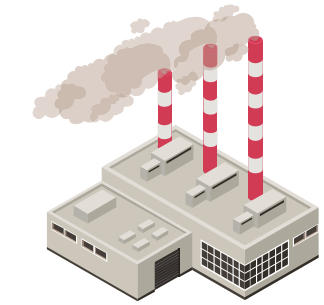
PM2.5 exposure has direct effect on the mental stress of pregnant women

Odds ratio: **13.76% (95 %CI: 8.26–19.53%)** per unit increase in ADD



- **Li**, et al. *Environ Int*, 2021.

Potential Mechanisms: *What factors might link air pollution exposure and mental health outcomes?*



Air pollution

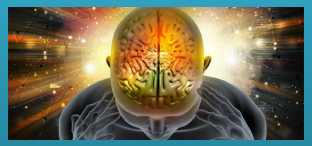
Mental Health Outcomes

- **Lowe** et al, *Environ Res,* 2020.

Potential Mechanisms: *What factors might link air pollution exposure and mental health outcomes?*

Air pollution

Biological: Oxidative and nitrosative stress; inflammation; HPA axis dysregulation



Physical health: Symptom exacerbation (e.g., asthma, COPD)

Psychosocial: Lower outdoor leisure, exercise, neighborhood social support

Mental Health Outcomes

- **Lowe** et al, *Environ Res,* 2020.

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Thank you!
Questions?

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