Air Pollution and Mental Health: Evidence from China
ONLINE APPENDIX

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January 12, 2024

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A Appendix Tables and Figures

Figures

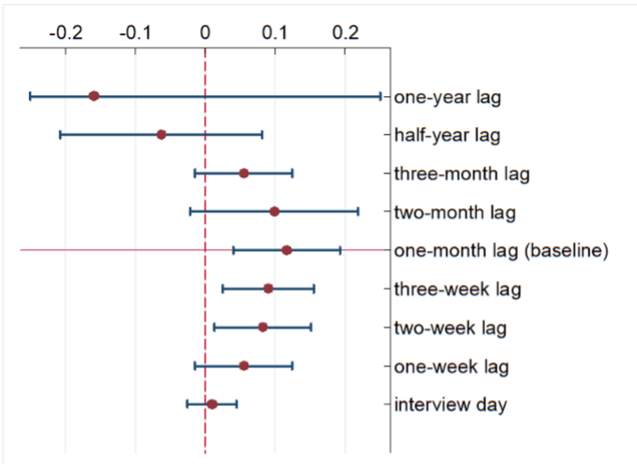

Figure A.1: Impact of PM2.5 on the K6 score

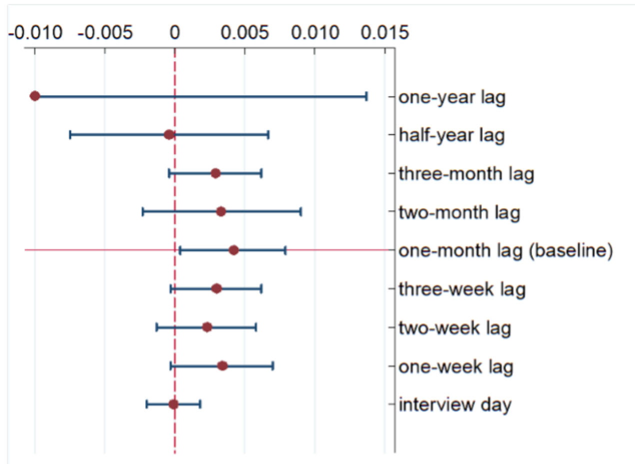

Figure A.2: Impact of PM2.5 on K6$\geq$12

Notes: This figure depicts the impacts of PM2.5 on the K6 score (Panel A) and severe mental illness (Panel B). PM2.5 is calculated using the average from the past year to past half-year, three months, etc., until the interview day. The circle denotes the point estimate, and the whisker denotes the 95% confidence intervals. The baseline is highlighted in red. Due to space limitations, we only present one side of the 95% confidence intervals for certain periods.

Tables

Table A.1: Summary Statistics

Variable	Unit	Mean	SD	Min	Max
Mental health					
K6 Score	Index (0-24)	2.94	3.76	0	24
Severe Mental Illness	%	4.38	20.47	0	100
Depression	0-never; 4-almost everyday	0.75	0.92	0	4
Nervousness	0-never; 4-almost everyday	0.59	0.87	0	4
Restlessness	0-never; 4-almost everyday	0.50	0.82	0	4
Hopelessness	0-never; 4-almost everyday	0.31	0.72	0	4
Difficulty	0-never; 4-almost everyday	0.51	0.85	0	4
Worthlessness	0-never; 4-almost everyday	0.28	0.69	0	4
Air Pollution					
PM2.5	$\mu g/m^3$	47.71	18.04	13.46	160.19
Thermal Inversions					
Inversions	Times	11.74	13.32	0	93

Notes: N=12,615. Unit of observation is individual. The survey covered 160 counties during the period of July 3rd, 2014 to March 31th, 2015. The interview surveyed the mental health within one month prior to the interview day for the adult population (age $\leq$ 16). The K6 score is the sum of the scores for the six individual symptoms. Severe mental illness is a dummy variable which equals to one if the K6 score is above or equal to 12 and zero otherwise. Each specific symptom is coded from zero to four, with zero indicating never, one a little of the time, two half of the time, three most of the time, and four almost every day. Daily pollutant concentrations are averaged to the month level. The existence of a thermal inversion is determined within each six-hour period, and then aggregated to the month level.

Table A.2: IV Estimation Results vs. OLS Estimation Results

	K6 Score		Severe Mental Illness	
	(1)	(2)	(3)	(4)
Panel A: IV				
PM2.5	0.1164***	0.0672**	0.0042**	0.0028**
	(0.0388)	(0.0291)	(0.0019)	(0.0013)
KP F-statistics	54.56	86.97	54.56	86.97
Panel B:OLS				
PM2.5	-0.0056	-0.0022	-0.0005	-0.0003
	(0.0078)	(0.0070)	(0.0005)	(0.0004)
Mean [SD] of Dep. Var.	2.9556	[3.7598]	(0.0438)	[0.2047]
County FE	Yes	Yes	Yes	Yes
Date FE	Yes	Yes	Yes	Yes
Weather Controls	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes
Sample Weight	Yes	No	Yes	No

Notes: N=12,615. The dependent variables are the K6 scores in columns (1)−(2) and severe mental illness in columns (3)−(4). Severe mental illness is a dummy variable which equals one if the K6 score is equal to or larger than 12. Panel A is the IV estimate, in which we use number of thermal inversions as an instrument for PM2.5. Panel B is the OLS estimate. Weather controls include 5 Â°C temperature bins, second-order polynomials in average relative humidity, wind speed, and sunshine duration, and cumulative precipitation. Standard errors are listed in parentheses and clustered by county-date. *** p<0.01, ** p<0.05, * p<0.1.

Table A.3: Robustness Checks by Alternative Clustering

Alternative clustering	By county	By date	County-by-week	County-by-month	Robust
	(1)	(2)	(3)	(4)	(5)
Panel A: K6 Score					
PM2.5	0.1164*	0.1164***	0.1164***	0.1164**	0.1164***
	(0.0618)	(0.0438)	(0.0435)	(0.0486)	(0.0367)
KP F-statistics	14.26	38.44	28.62	20.67	106.5
Panel B: Severe Mental Illness					
PM2.5	0.0042	0.0042**	0.0042**	0.0042*	0.0042**
	(0.0028)	(0.0020)	(0.0021)	(0.0022)	(0.0019)
KP F-statistics	14.26	38.44	28.62	20.67	106.5

Notes: N=12,615. The dependent variables consist of the K6 score in Panel A and a dummy variable for severe mental illness in Panel B. Columns (1)−(5) test the robustness of clustering standard errors. Our baseline model clusters standard errors at the county-date level. Columns (1) and (2) cluster standard errors at either the county or date level, while Columns (3)−4) cluster standard errors at either the county-by-week or county-by-month level. Column (5) presents robust standard errors for additional comparison. All models include county fixed effects, date fixed effects, and weather controls. Standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

B Data Appendix

B.1 Thermal Inversion Data Aggregation

MERRA-2 divides the Earth into a 0.5 × 0.625-degree grid (around 50 × 60-km grid), and reports the air temperature for each 42 sea-level pressure layer for every six hours starting from 1980. We aggregate thermal inversions at the month-county level. First, we construct a thermal inversion indicator at the county-six-hour level by taking the average of temperatures across grid points within a county for the first layer (110 m) and separately for the second layer (320 m).[1] For each six hour period and for each layer, we define a thermal inversion as an indicator variable for whether the average county-level temperature in the first layer is lower than that in the second layer. Second, we aggregate the number of thermal inversions in the month prior to each interview date and match it to each respondent in the CFPS data by county and date of interview.[2]

Chen, Shuai, Paulina Oliva, and Peng Zhang. 2022. The effect of air pollution on migration: Evidence from China. Journal of Development Economics, 156: 102833.

Fu, Shihe, V. Brian Viard, and Peng Zhang. 2021. Air pollution and manufacturing firm productivity: Nationwide estimates for China. The Economic Journal, 131(640): 3241-3273.

Hijmans R.J., Van Etten J. 2016. Raster: Geographic data analysis and modeling. R package version, 2(8).

[1]If the altitude of the county is above 110 m, the temperature data in that layer is missing. We thus use the closest layer that has no-missing value. We also conduct a robustness check by using the third layer (540 m).

[2]Because the original grid is at 50 × 60-km, we downscale to 10 × 12-km grid using the bilinear method (Hijmans et al., 2015). We then take the weighted average for all small grids within the same county (Fu et al. 2021, Chen et al. 2022)