Traffic-related air pollutants and their health effects in Beijing

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The total number of vehicles on Chinese roads has broken 250 million, increased by 6 times in 10 years. China has been the No.1 automotive market in the world since 2009.

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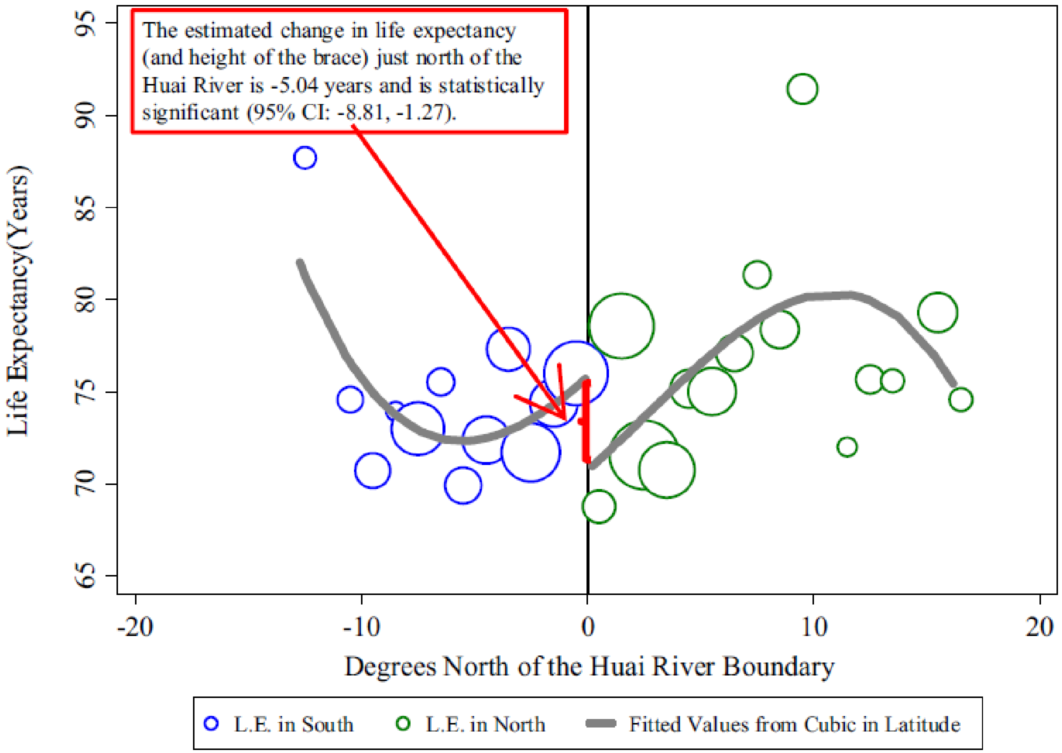
China, the No.1 greenhouse gases emitter, produces 9680 Mt CO_2 a year accounting for one fourth of total global CO_2 emission, 2.5 times of EU 28 countries' total emission.

Less than 1 percent of China's 500 largest cities meet the WHO's air quality standards.

Guideline values
$PM_{2.5}$
10 μg/m^3 annual mean
25 μg/m^3 24-hour mean
PM_{10}
20 μg/m^3 annual mean
50 μg/m^3 24-hour mean

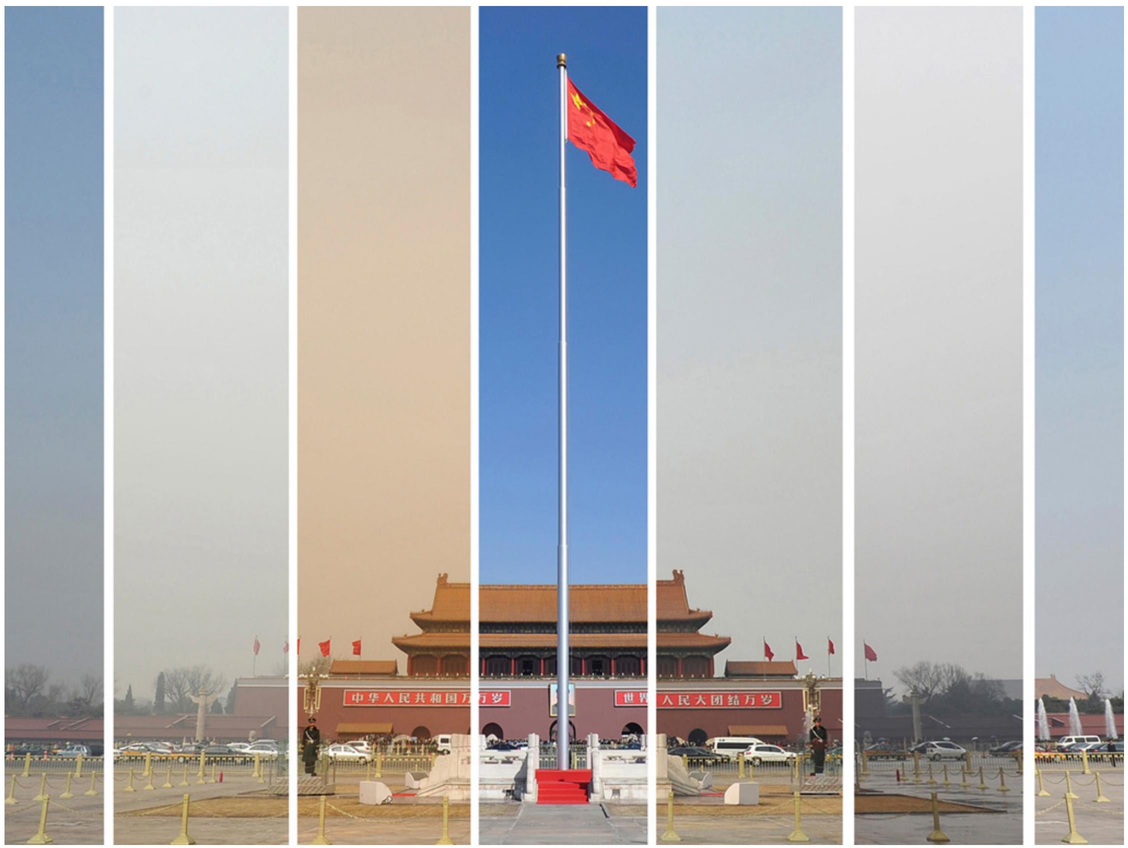
A maximum 5.5-year decrease in life expectancy in the northern Chine was associated with air pollution.

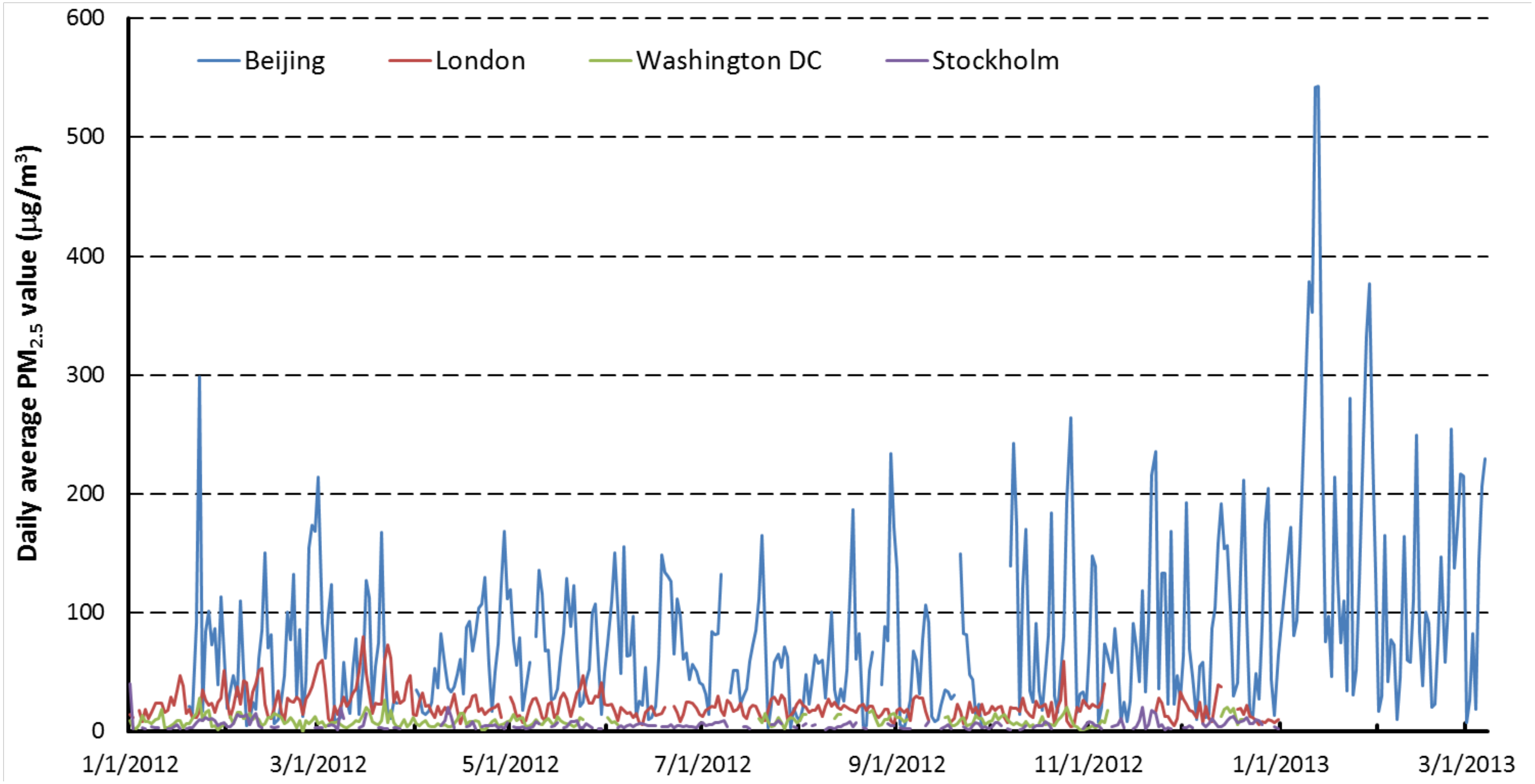


*Evidence on the impact of sustained exposure to air pollution on life expectancy from China's Huai River policy
Yuyu Chen, Avraham Ebenstein, Michael Greenstone, and Hongbin Li

Situation in Beijing

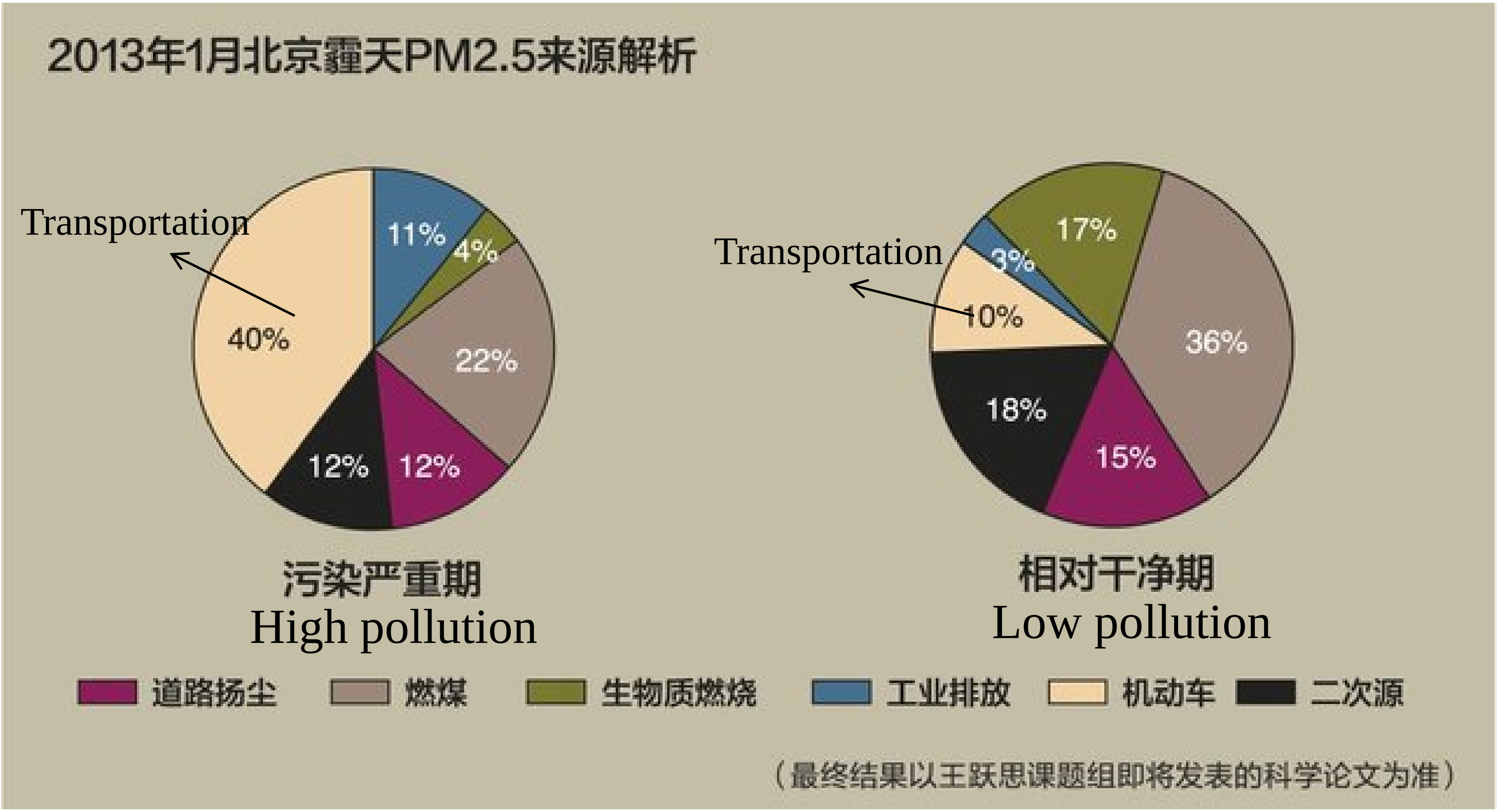
The highest PM2.5 concentration approached to 1000 μg/m^3 in Beijing on Jan 12, 2013





Data sources: Beijing Municipal Environmental Protection Bureau, not published; United States Environmental Protection Agency; London Air Quality Network; Stockholm Uppsala County Air Quality Management Association, not published)

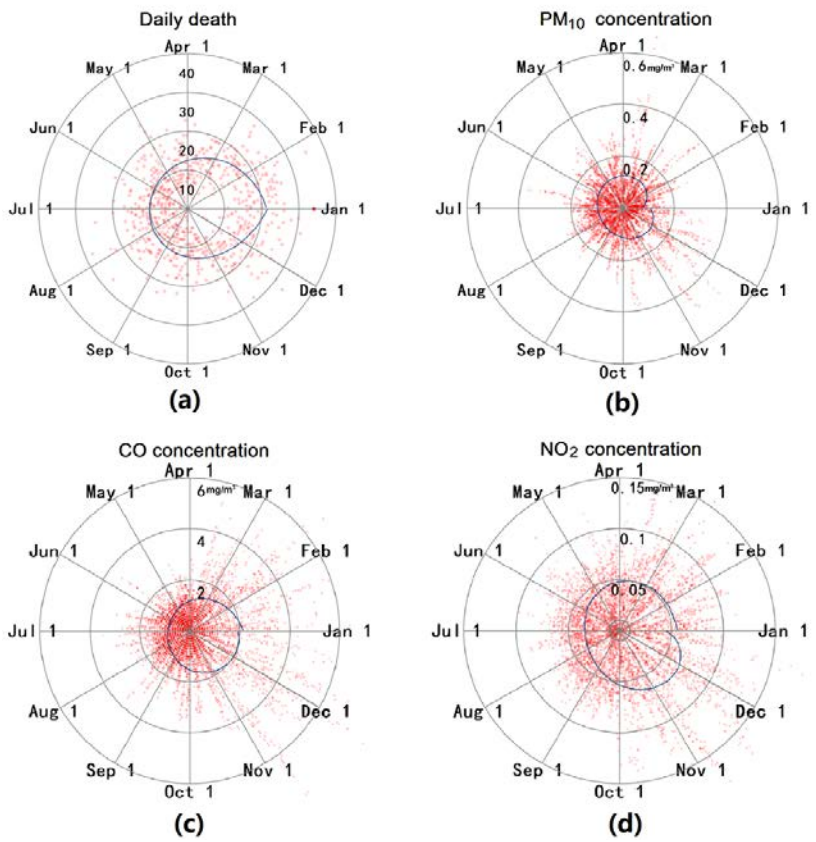
Resources of PM2.5

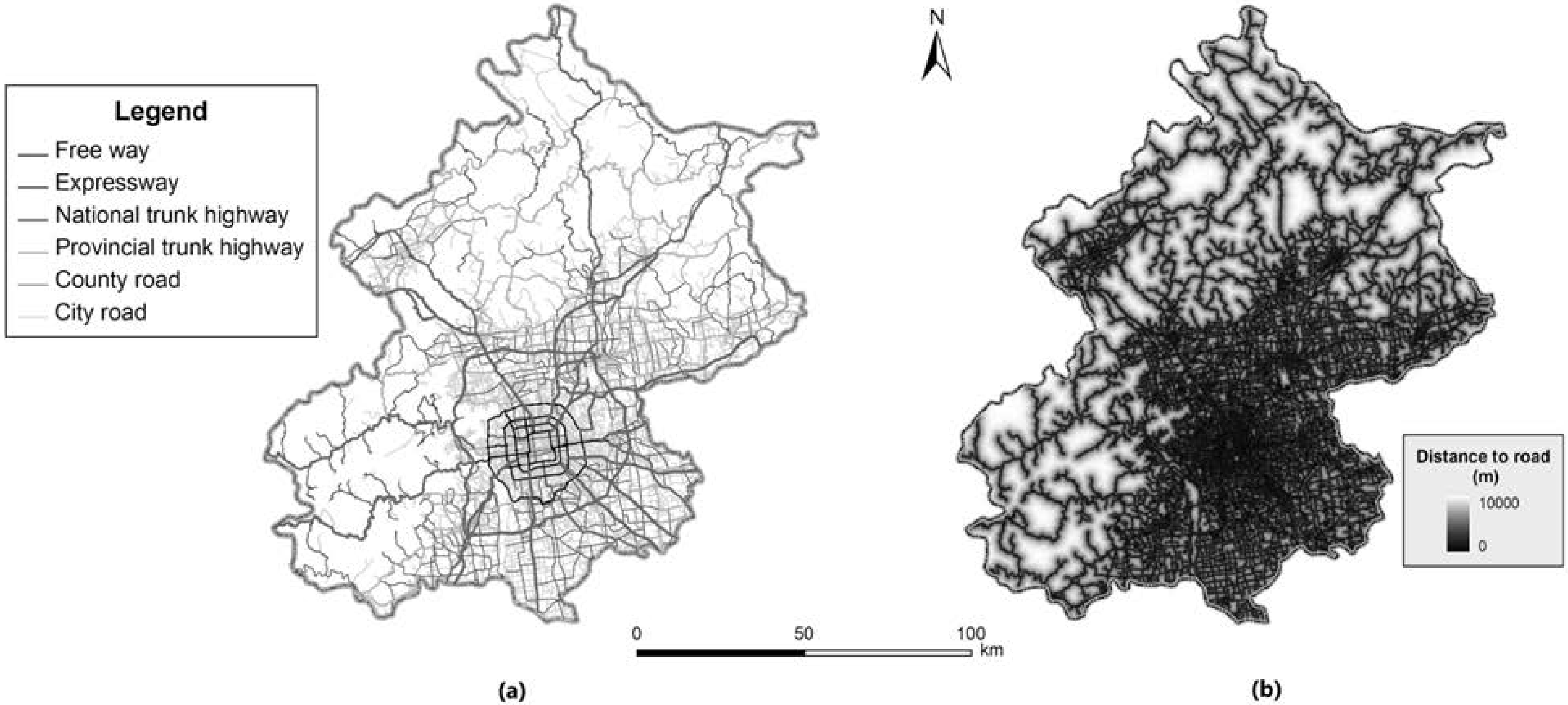


BREATH (Beijing Respiratory Effects And Traffic-related Pollutants) Study

Citywide daily deaths (a) and daily pollutant concentrations (b, c, d) of 12 AQM stations in Beijing during 730 days between January 1, 2009 to December 31, 2010

Weather condition data during the same time period





Beijing road traffic system(a) and road density(b)

What we have done

Association between ambient air pollution and daily mortality in Beijing after the 2008 Olympics: a time series study.

Yang, Y., Li, R., Li, W., Wang, M., Cao, Y., Wu, Z., & Xu, Q. (2013). The PloS one, 8(10), e76759.

	Mean ± SD	Min*	P(25)**	P(50)**	P(75)**	Max***
Daily death counts						
Nonaccidental	200.4±28.7	135	180	198	221	282
Cardiovascular	101.0±19.8	39	86	99	115	80
Respiratory	20.6±6.0	7	16	20	24	47
Air pollutants concentrations[a]						
CO (mg/m^3)	1.54±1.01	0.27	0.87	1.24	1.84	7.79
NO_2 (μg/m^3)	55.02±24.04	9.90	39.27	50.41	64.36	180.67
PM_{10} (μg/m^3)	121.04±75.30	4.91	69.00	107.00	149.00	651.18
Weather						
Temperature (°C)	13.0±11.7	−12.5	1.7	14.7	24.3	34.5
Humidity (%)	51.0±19.2	13	35	52	67	92
Barometric pressure (hPa)	1012±9.8	989.7	1004.4	1011.2	1019.2	1037.1

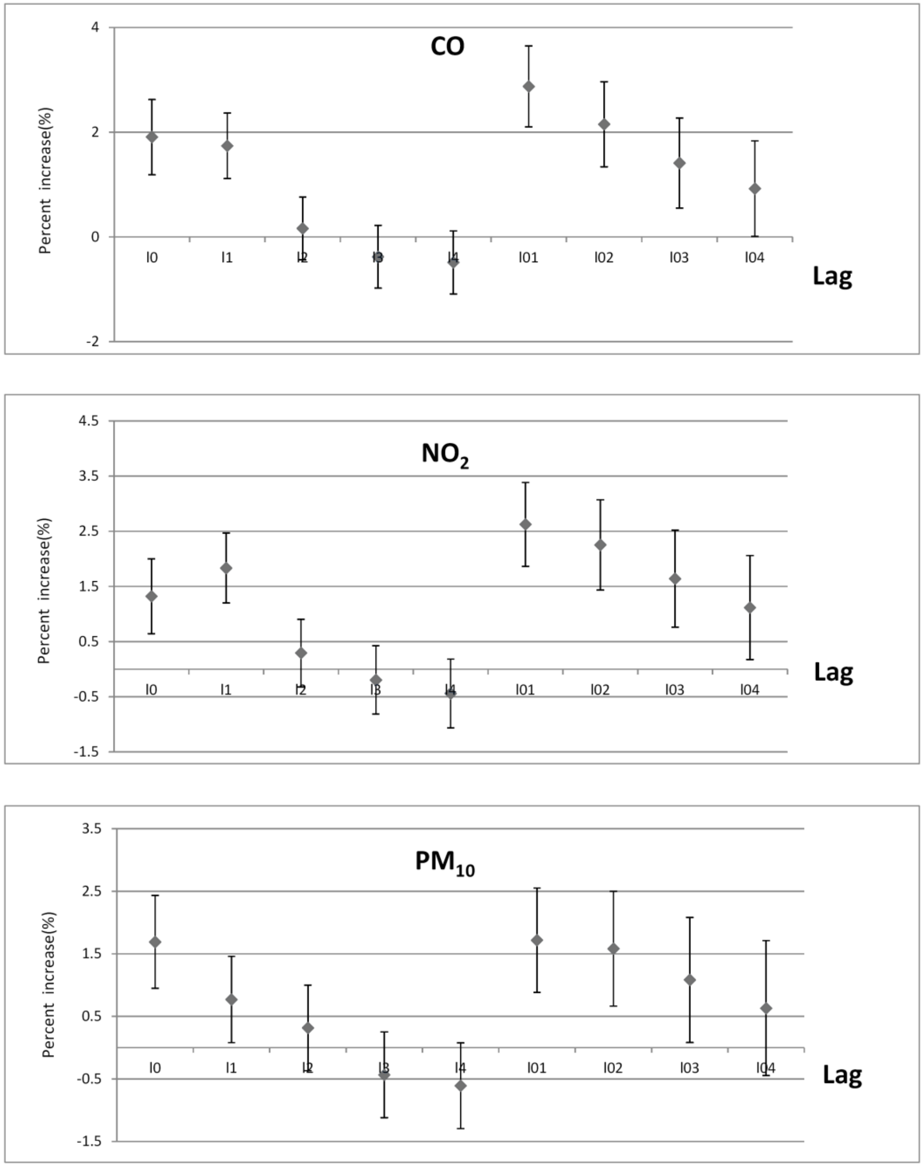
[a]Twenty-four-hour average for CO, NO_2 and PM_{10}.
*minimum.
**the 25th, 50th (median) and 75th percentile, respectively.
***maximum.
doi:10.1371/journal.pone.0076759.t001

Percent increase of daily mortality associated with an IQR increase of CO, NO2 and PM10 with single model and principal component analysis in Beijing (mean and 95% CI), using 8 df/year

	Nonaccidental mortality	Cardiovascular mortality	Respiratory mortality
Single model			
CO	2.55 (1.99, 3.11)*	2.88 (2.10, 3.65)*	2.39 (0.68, 4.09)*
NO_2	2.54 (2.00, 3.08)*	2.63 (1.87, 3.39)*	1.79 (0.11, 3.47)*
PM_{10}	1.80 (1.21, 2.40)*	1.72 (0.88, 2.55)*	2.07 (0.21, 3.92)*
After-adjusting collinearity by principal component analysis			
CO	0.97 (0.77, 1.17)*	1.01 (0.73, 1.29)*	0.89 (0.27, 1.51)*
NO_2	1.04 (0.82, 1.25)*	1.08 (0.78, 1.38)*	0.95 (0.29, 1.61)*
PM_{10}	1.07 (0.85, 1.30)*	1.12 (0.81, 1.43)*	0.99 (0.30, 1.67)*

[a]We applied current-day (lag 0 day) temperature and relative humidity and 2-day moving average of air pollutant concentrations (lag01), and applied 8 df per year for time, 3 df to temperature, humidity and barometric pressure.
*$P<0.05$.
doi:10.1371/journal.pone.0076759.t003

Percent increase of daily cardiovascular mortality associated with an IQR increase of CO, NO2 and PM10 concentrations, using different lag structure of pollutants.



Multi-site Time Series Analysis of Acute Effects of Multiple Air Pollutants on Respiratory Mortality: a Population-based Study in Beijing, China

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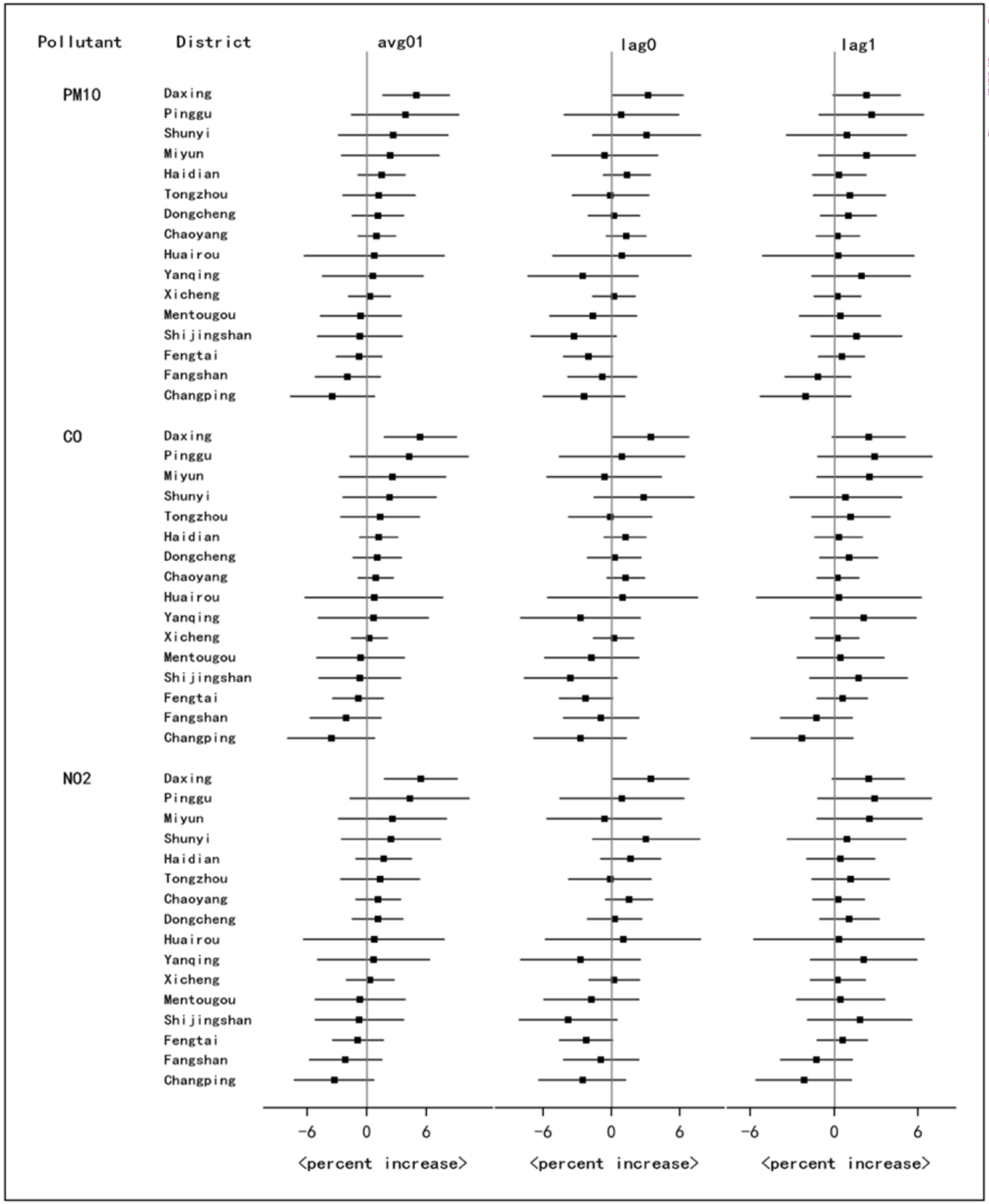
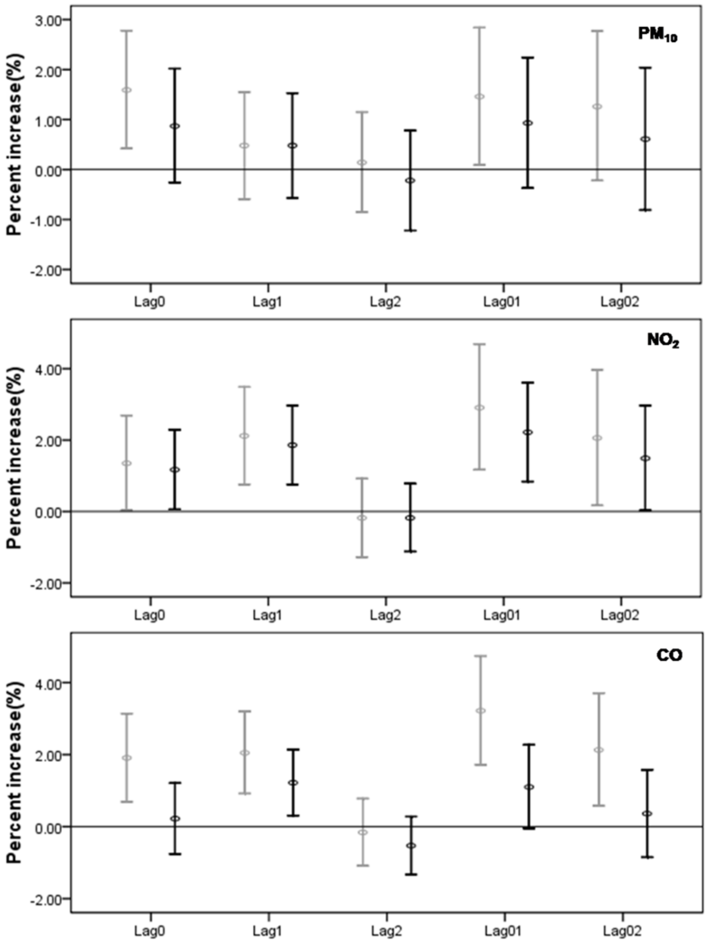
Districts	Death		PM_{10}(μg/m^3)		CO(mg/m^3)		NO_2(μg/m^3)	
	Mean	SD	Median	IQR	Median	IQR	Median	IQR
Dongcheng	1.85	1.39	110.3	85.5	1.40	1.10	54.0	26.0
Xicheng	2.58	1.55	105.5	82.0	1.40	1.00	59.0	29.0
Chaoyang	3.25	1.97	106.5	84.0	1.30	1.00	56.0	30.0
Fengtai*	2.14	1.57	99.8	22.7	1.17	0.69	42.9	17.5
Shijingshan	0.78	0.85	129.0	90.5	1.40	1.00	50.0	28.0
Haidian	2.54	1.65	112.0	83.0	1.20	1.20	54.0	34.0
Mentougou*	0.81	0.90	92.7	21.5	0.99	0.57	33.9	15.0
Fangshan*	1.18	1.17	93.4	21.6	1.01	0.58	34.7	15.3
Tongzhou*	0.93	0.97	96.3	22.0	1.08	0.63	38.3	16.1
Shunyi	0.68	0.81	108.5	88.0	0.90	0.80	43.5	26.0
Changping	0.97	0.99	94.0	81.0	1.20	0.90	41.0	25.0
Daxing*	0.98	1.07	96.3	22.0	1.08	0.62	38.2	16.0
Huairou	0.42	0.66	82.5	75.0	1.00	0.80	30.0	26.0
Pinggu*	0.42	0.69	93.8	21.6	1.02	0.59	35.2	15.4
Yanqing*	0.51	0.75	92.9	21.5	1.00	0.57	34.1	15.1
Miyun*	0.51	0.74	92.8	21.5	0.99	0.57	34.0	15.1
Total	20.55**	5.99	96.3	46.6	1.10	0.80	40.8	25.0

Percentage increase of daily respiratory deaths associated with an IQR increase in pollutant concentrations in16 districts of Beijing, China, adjusting for collinearity.



The spatial variation in the effects of air pollution on daily cardiovascular mortality in Beijing, China

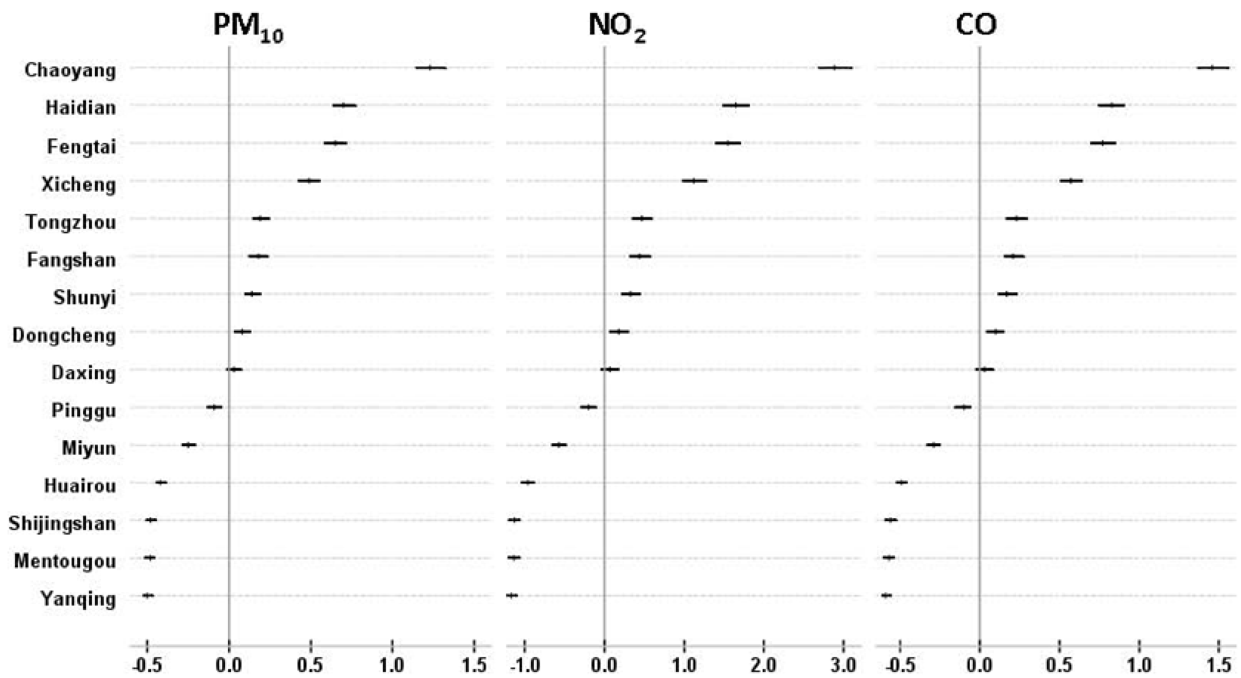
Percent increase of daily cardiovascular mortality associated with an IQR increase of air pollutant concentration from GAMM (denoted by black line) and GAM (denoted by gray line)in the whole area of Beijing, China from 2009 to 2010



$$Log\big(E(Y_t)\big) = \beta_0 + s(time_t, 8) + s(temperature_t, 3) + s(humidity_t, 3) + \beta_1(DOW_t) + \beta_2(pollution_t) + \varepsilon_i$$

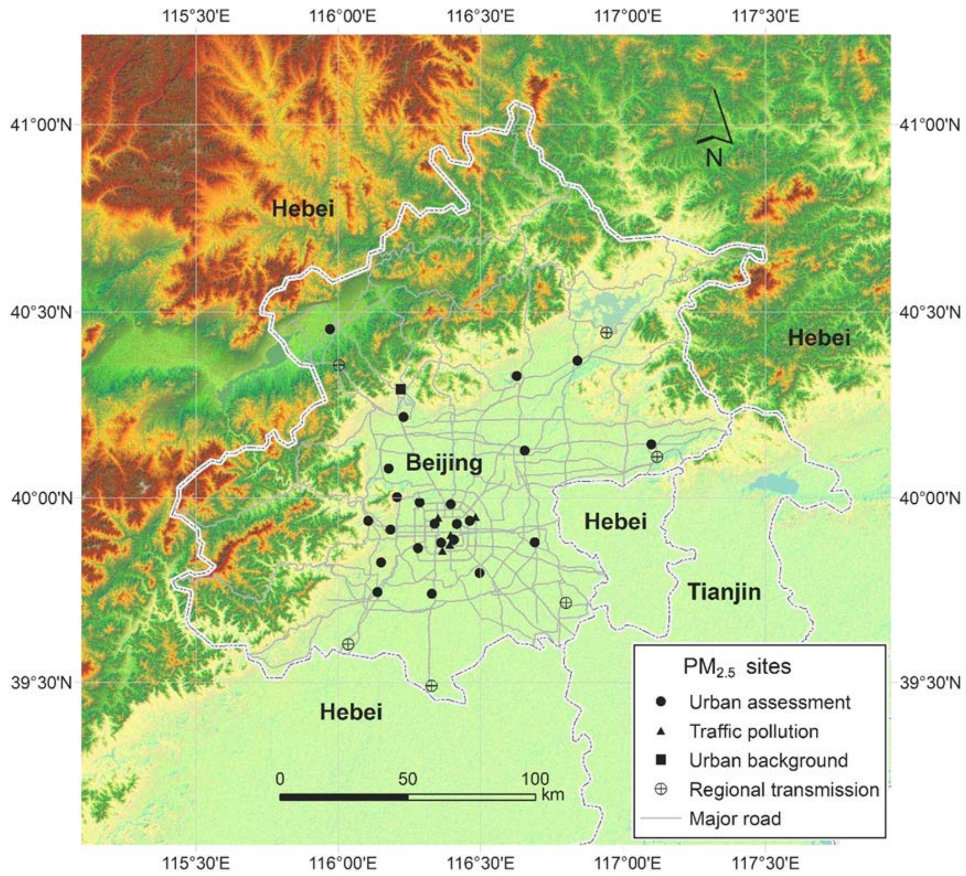
ε_i is the random effect for district *i*

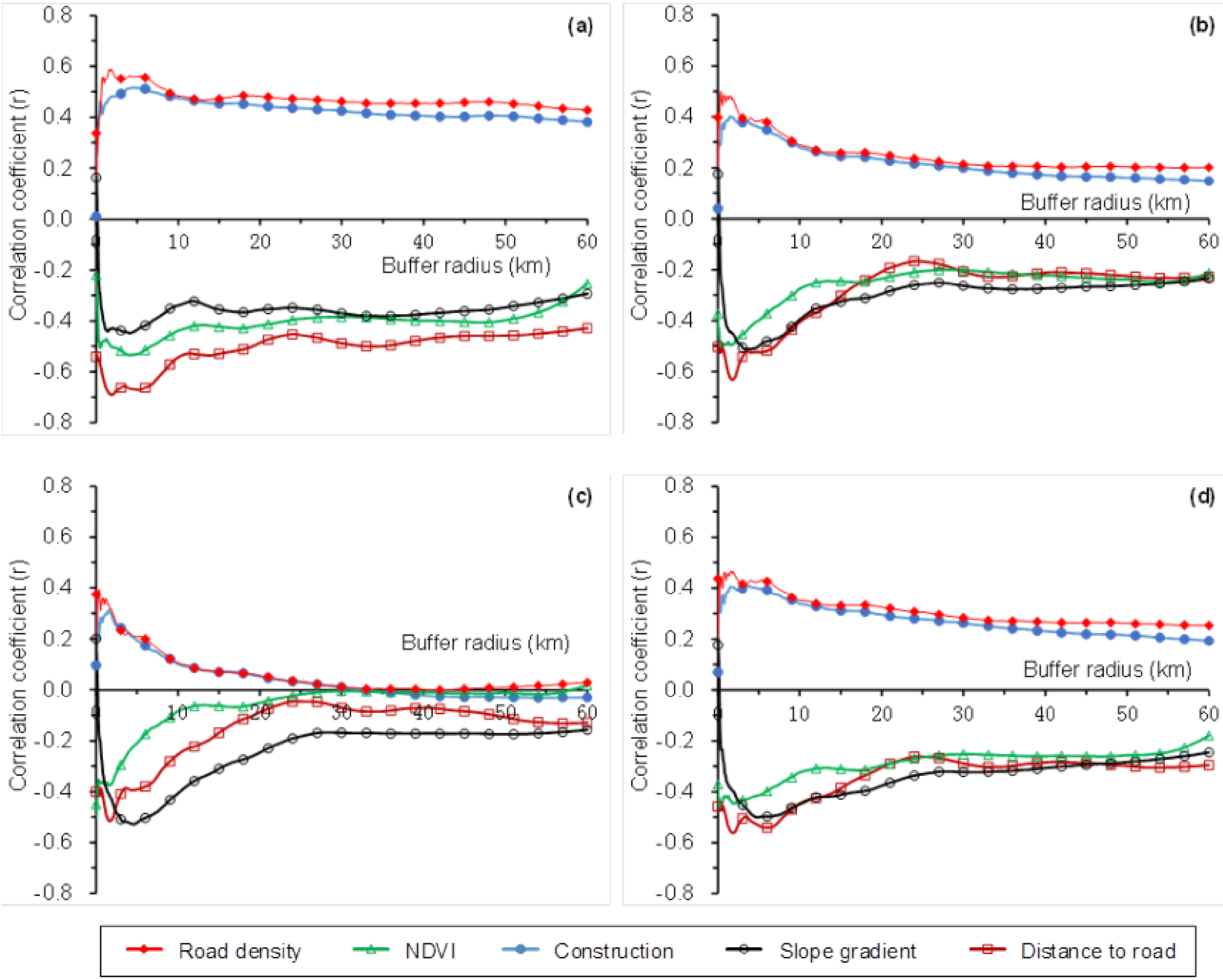
$$Log\big(E(Y_t)\big) = \beta_0 + s(time_t, 8) + s(temperature_t, 3) + s(humidity_t, 3) + \beta_1(DOW_t) + \beta_2(pollution_t)$$



The effect increments (the differences between the estimation of effect of every other district and Changping) in daily cardiovascular mortality associated with an IQR increase in air pollutant concentrations, based on GAMM in Beijing, China from 2009 to 2010

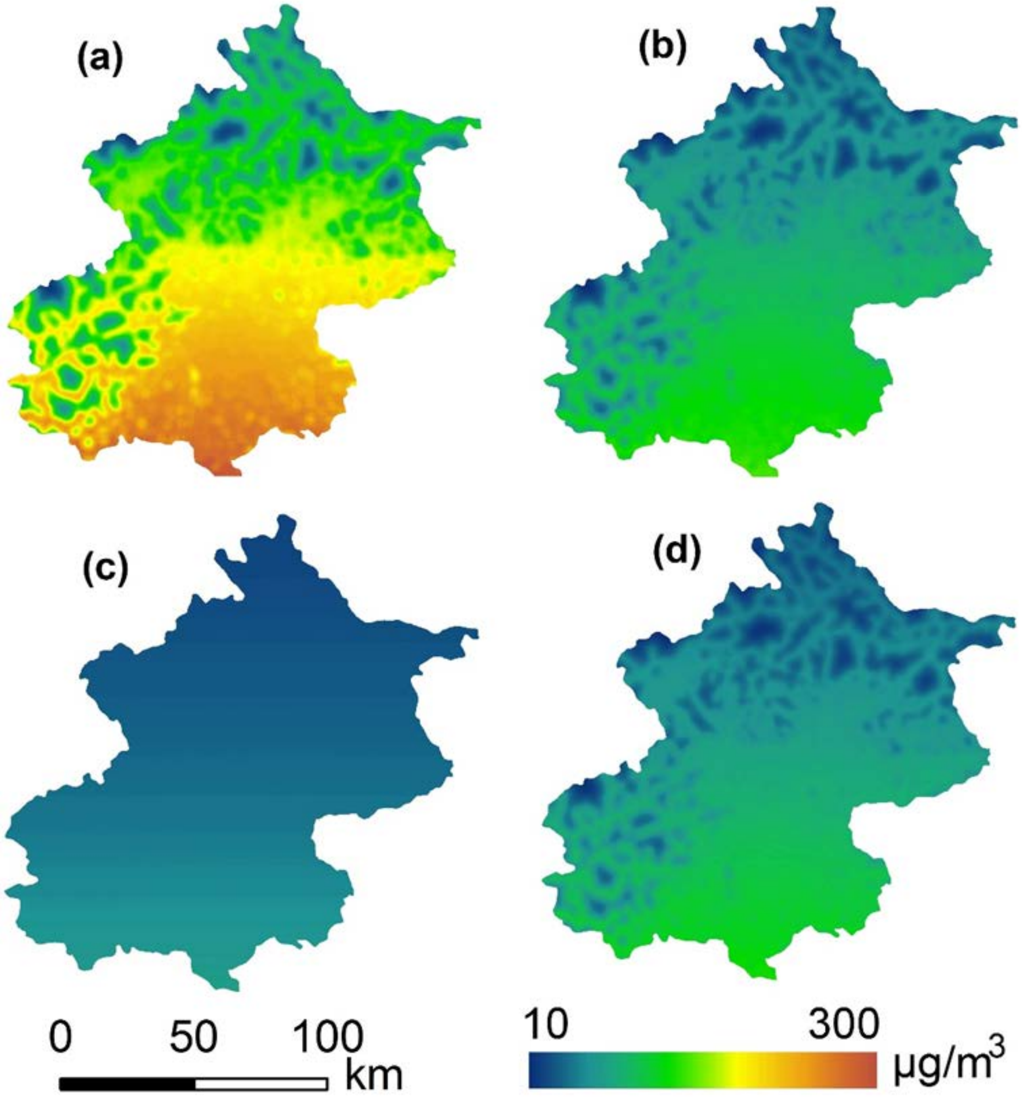
Fine-grained mapping of PM2.5 based on land use regression model in Beijing, China





Correlation coefficients of the land use variables with observed pollution at different pollution levels. (a) High; (b) Medium; (c) Low; (d) The whole study period

Projected spatial distribution of PM2.5 concentration at different pollution levels. (a) High; (b) Medium; (c) Low; (d) The whole study period



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Future plan

From Floor to Ceiling - A comparative study on dose-response relationship between traffic-related air pollutants and cardiovascular/respiratory mortality at two extreme ends of the world

To investigate the dose-response relationship between cardiovascular/respiratory mortality and several important traffic-related air pollutants, including PM10, PM2.5, nitrogen oxides (NOx), nitric oxide (NO), Sulfur dioxide (SO2) and carbon monoxide (CO), in the range between two extreme scenarios, where annual air quality indices (of PM2.5) are lower than 20 and higher than 100, respectively.

Dose-response relationship between air pollution and mortality

Querol X, Alastuey A, Ruiz CR, et al. Speciation and origin of PM10 and PM2.5 in selected European cities. *Atmos Environ* 2004;38(38):6547-55.
Samoli E, Analitis A, Touloumi G, et al. Estimating the exposure-response relationships between particulate matter and mortality within the APHEA multicity project. *Environ Health Persp* 2005;113(1):88-95.

Question 1:

How to avoid the effect of concurvity between pollutants in time series study of air pollution?

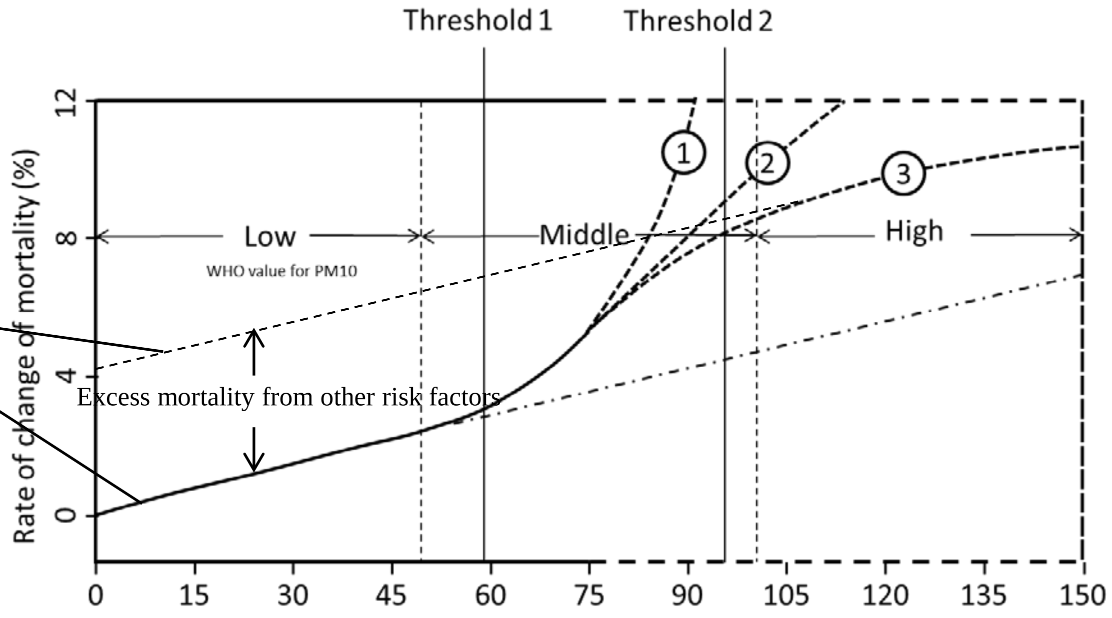
Co-exposure and attributable risk

	NO_2	PM_{10}	Temperature	Humidity	Barometric pressure
CO	0.86*	0.58*	-0.33*	0.35*	0.10*
NO_2		0.55*	-0.23*	0.27*	0.05*
PM_{10}			-0.02	0.22*	-0.19*
Temperature				0.33*	-0.83*
Humidity					-0.31*

Question 2:

Are the dose-response effects of air pollutants on cardiovascular mortality different between low-level exposure and high-level exposure contexts?

The same trend



Question 3:

Because of the inevitable role of extreme weather on air pollution or inverse, is the interaction between extreme weather conditions and air pollutants on cause-specific mortality synergistic or additive?

Acknowledgement

Internal collaborators:

- Matteo Bottai, Professor, Unit of Biostatistics, IMM, KI
- Xin Fang, PhD student, Unit of Biostatistics, IMM, KI
- Qing Shen, PhD srudent, Unit of Biostatistics, IMM, KI

External collaborators:

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- Runkui Li, Lecturer, College of Resources and Environment, University of Chinese Academy of Sciences, Beijing
- Yang Yang, Wang Meng, Wenjing Li, Department of Epidemiology and Biostatistics, Institute of Basic Medical Sciences of Chinese Academy of Medical Sciences &School of Basic Medicine of Peking Union Medical College, Beijing

Thanks!