Supplementary Material

Overall Summary Descriptive

During the study period of 2015–2017 and 2018–2020, the total number of non-accidental deaths increased from 31 to 39, with an increase of 8 in total deaths, including an increase of 6 deaths from circulatory diseases (from 16 to 22) and an increase of one death from circulatory diseases (from 4 to 5) (Supplementary Table S1). The annual average concentration of fine particulate matter ($PM_{2.5}$) decreased from 91.1 μg/m^3 to 64.1 μg/m^3, a decrease of 29.64%, but still exceeded the annual average concentration limit (the secondary limit of 35 μg/m^3 in China and 10 μg/m^3 in WHO). Temperature and humidity remained stable.

Spearman's Correlation Coefficients

As show in Supplementary Table S2, the relationship between $PM_{2.5}$ and four pollutants or two meteorological

SUPPLEMENTARY TABLE S1. Overall summary descriptive statistics of daily mortality, $PM_{2.5}$ and meteorological data in Shijiazhuang for two periods (2015–2017 and 2018–2020).

Variable	Period	Mean (SD)	Min	P_{25}	P_{50}	P_{75}	Max
Daily mortality							
ALL	2015–2017	31 (8)	12	25	30	36	69
ALL	2018–2020	39 (10)	17	32	38	44	107
CVD	2015–2017	16 (5)	4	12	16	19	43
CVD	2018–2020	22 (7)	6	17	21	25	67
RESP	2015–2017	4 (2)	0	3	4	6	31
RESP	2018–2020	5 (3)	0	3	5	6	16
Air pollutant (μg/m^3)							
$PM_{2.5}$	2015–2017	91.1 (79.4)	6.3	40.3	66.2	112.0	625.3
$PM_{2.5}$	2018–2020	64.1 (50.5)	9.0	31.6	47.4	78.0	355.0
Weather conditions							
Temp (℃)	2015–2017	14.8 (10.6)	−10.2	4.6	16.1	24.4	33.2
Temp (℃)	2018–2020	14.8 (11.0)	−7.4	4.6	15.9	25.0	33.7
RH (%)	2015–2017	55.9 (20.8)	13	39	55	73	98
RH (%)	2018–2020	55.2 (19.9)	7	40	55	70	100

Abbreviations: ALL=total non-accidental mortality from all causes; CVD=cardiovascular disease; RESP=respiratory disease; $PM_{2.5}$=particulate matter with an aerodynamic diameter less than or equal to 2.5 μm; Temp=average temperature; RH=relative humidity; SD=standard deviation; Min=minimum; P_{25}=the 25th percentile; P_{50}=the median; P_{75}=the 75th percentile; Max=maximum.

SUPPLEMENTARY TABLE S2. Spearman correlations between air pollutants and weather conditions in Shijiazhuang from 2015 to 2020.

Variables*	PM_{10}	SO_2	NO_2	O_3	Temperature	Humidity
$PM_{2.5}$	0.92*	0.58*	0.65*	−0.33*	−0.43*	0.23*
PM_{10}		0.64*	0.72*	−0.27*	−0.38*	0.02
SO_2			0.69*	−0.23*	−0.40*	−0.35*
NO_2				−0.44*	−0.49*	−0.07*
O_3					0.80*	−0.09*
Temperature						0.13*

Abbreviations: $PM_{2.5}$=particulate matter with an aerodynamic diameter less than or equal to 2.5 μm; PM_{10}=particulate matter with particle size below 10 microns.

* $P<0.01$.

conditions is illustrated. Spearman's correlation coefficients between $PM_{2.5}$ and particulate matter with particle size below 10 microns (PM_{10}), SO_2, NO_2 were all positive. In contrast, the relationship between $PM_{2.5}$ and O_3 was negatively correlated. Temperature and humidity were both important factors for $PM_{2.5}$. Coefficients of −0.43 and 0.23 were observed between $PM_{2.5}$ and temperature and relative humidity, respectively.

Model Description

We controlled for the day of the week and holidays using factor variables. The model can be described as follows: *logE (Yt) = β Zt + ns (time, df = 7/year) +ns (temperature, df = 6) + ns (humidity, df = 3) + as.factor (DOW) + as.factor (Holiday) + intercept*, where "*E(Yt)*" is the expected cause-specific death numbers on day t, " *β* " represents the logrelated rate of cause-specific mortality associated with a unit increase of $PM_{2.5}$, "*df*" represents degree of freedom ,"*DOW*" is a dummy variable for the day of the week, "*Holiday*" is a binary dummy variable for the public holiday, and "*ns*" indicates natural cubic regression smooth function. We examined the associations with different lag structures from lag0 (current day) up to lag7, as well as moving averages for the current day and the previous one to seven days: from lag01 to lag07. The exposure-response relationship curves between $PM_{2.5}$ and cause-specific mortality also were plotted.

Sensitivity Analyses and Two-Pollutant Models

We performed sensitivity analyses to assess the robustness of our estimates for the associations between $PM_{2.5}$ and cause-specific mortality. First, we changed the degrees of freedom (*df*) in the smoothness of time from 5 to 9 *df*/year. In addition, we fit two-pollutant models with adjustment for concomitant exposure to O_3.

Supplementary Table S3 summarizes the association between $PM_{2.5}$ and total non-accidental (ALL), cardiovascular (CVD), and respiratory (RESP) mortality after adjusting temporal trends by alternative degrees of freedom (5–9/year). Furthermore, although the estimates for association were changed marginally, they still remained statistically significant.

Supplementary Table S4 compared the results of the two pollutant models, after adjusting for $O_{3,}$ with the results of the single pollutant models. The estimated effects of $PM_{2.5}$ on ALL, CVD, and RESP mortality remained

SUPPLEMENTARY TABLE S3. Percent change (95% CI) in ALL, CVD, and RESP mortality per 10 μg/m^3 increase in 2-day moving average concentrations of $PM_{2.5}$ (lag01) using different degrees of freedom per year.

***df*/year**	**ER (%)**		
	ALL (95% CI)	**CVD (95% CI)**	**RESP (95%*CI*)**
5	0.52 (0.29, 0.75)*	0.53(0.23, 0.83)*	0.81(0.31, 1.32)*
6	0.54 (0.31, 0.78)*	0.56 (0.25, 0.86)*	0.82 (0.31, 1.33)*
7	0.47 (0.24, 0.70)*	0.49 (0.19, 0.79)*	0.72 (0.22, 1.23)*
8	0.46 (0.23, 0.69)*	0.47 (0.17, 0.77)*	0.74 (0.23, 1.25)*
9	0.47 (0.25, 0.70)*	0.50 (0.20, 0.80)*	0.73 (0.22, 1.24)*

Abbreviations: ALL=total non-accidental death; CVD=cardiovascular disease; RESP=respiratory disease; $PM_{2.5}$=particulate matter with an aerodynamic diameter less than or equal to 2.5 μm; *df*=degree of freedom; ER=excess risk; CI=confidence interval.

* *P*<0.05.

SUPPLEMENTARY TABLE S4. Percent change (95% CI) in ALL, CVD, and RESP mortality per 10 μg/m^3 increase in 2-day moving average concentrations of $PM_{2.5}$ (lag01) in two-pollutant models.

Models	**ER (%)**		
	ALL (95% CI)	**CVD (95% CI)**	**RESP (95% CI)**
$PM_{2.5}$	0.47 (0.24, 0.70)*	0.49 (0.19, 0.79)*	0.72 (0.22, 1.23)*
$PM_{2.5}$ + O_3	0.48 (0.24, 0.71)*	0.50 (0.19, 0.80)*	0.73 (0.22, 1.24)*

Abbreviations: ALL=total non-accidental death; CVD=cardiovascular disease; RESP=respiratory disease; $PM_{2.5}$=particulate matter with an aerodynamic diameter less than or equal to 2.5 μm; *df*=degree of freedom; ER=Excess Risk; CI=confidence Interval.

* *P*<0.05.

statistically significant.

Stratification Analyses

We stratified analyses by demographic factors, sex, age, and education; we tested for statistical significance of differences between effect estimates of the strata of a potential effect modifier by calculating the 95 percent confidence interval (95% CI) as $(\hat{Q}_1 - \hat{Q}_2) \pm 1.96\sqrt{(S\hat{E}_1)^2 + (S\hat{E}_2)^2}$, where $\hat{Q}_1$ and $\hat{Q}_2$ are the estimates for the two categories, $S\hat{E}_1$ and $S\hat{E}_2$ are their respective standard errors.