Atmosphere **2018**, *9*, 424; doi:10.3390/atmos9110424

Supplemental information

Ambient $PM_{2.5}$ human health effects – Findings in China and Research Directions

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Table S1. Major sources of $PM_{2.5}$ in Beijing by receptor modeling. Source contrition (%) in parenthesizes (columns 4-10) when available.

Authors	**Study Period**	**Methods**	**Sources**						
			Secondary	**Coal burring**	**Dust**	**Vehicle**	**Biomass**	**Industry**	**Others**
Zheng et al., 2005 [36]	January, April, July, and October, 2000	Chemical Mass Balance	· Secondary sulfate (17) · Secondary nitrate (10) · Secondary ammonium (6)	Coal combustions (7)	Dust (20)	Diesel and gasoline exhaust (7)	Biomass aerosol (6)		
Song et al., 2006 [39]	January, April, July, and October, 2000	Positive Matrix Factorization (PMF)	· Secondary sulfate (17) · Secondary nitrate (14)	Coal combustions (19)	Road dust (9)	Motor vehicles (6)	Biomass burning (11)	Industry (6)	
Zhang et al., 2013 [22]	April 2009 to January 2010	PMF	Secondary inorganic aerosol (26)	Coal combustions (14)	Soil dust (16)	Traffic and waste incineration emission (3)	Biomass burning (13)	Industrial pollution (28)	
Yu et al., 2013 [40]	January to December, 2010	PMF	Secondary sulphur (26.5)	Fossil fuel combustions (15.6)	· Soil dust (10.4) · Road dust (12.7)	Vehicle exhaust (17.1)	Biomass burning (11.2)	Metal processing (6)	

Jin et al., 2015 [24]	2007 to 2013	PMF		Coal burning (29.2)	Soil (15.4)	Vehicle exhaust and waste incineration (26.3)		Industrial with chlorine (5.9)	Constructio n industry (23.3)
Cao et al., 2002 [41]	December 1998 to February 2000	Factor Analysis			Soil and fly ash	Motor vehicle exhaust and coal burning		Nonferrous metal research institutes or factories	· Refuse incineration sites and construction working stations · Sea spray origin · Paint pigment
Sun et al., 2004 [23]	June, July, and December, 2002	Factor Analysis	Secondary	Coal burning	Road dust	Motor vehicles		· Metallurgical emissions · Nonferrous metal smelter	

Table S2. Summary of health effects studies, including PM2.5 concentrations measured, health outcomes investigated, approaches, and major findings.

Authors	**Study Period**	**Study Location**	**Measured $PM_{2.5}$ Concentrations**	**Health Outcome**	**Approach**	**Major findings**
Guo et al., 2009 [25]	2004 - 2006	Peking University site	Average over study period was 121.6 μg/m^3	Daily hospital visits for cardiovascular disease (CVD)	Case-crossover	1.005% increase in emergency room visits for CVD per 10 μg/m^{3}increase in $PM_{2.5}$.
Guo et al., 2010 [44]	2007	Peking University site	Average over study period was 102.4 μg/m^3	Emergency hospital visits (EHV) for hypertension	Time-stratified case-crossover	An increase of 10 μg/m^3 in $PM_{2.5}$ concentration was associated with increased EHVs for hypertension with an odds ratio of 1.084.
Chen et al., 2011 [26]	2007-2008	Urban areas in Beijing	82 μg/m^3 (24 hr average)	Cardiovascular and respiratory mortality	Time-series	Average elevation in daily cardiovascular and respiratory mortality of 0.58% and 0.66% per 10 μg/m^3 increase in $PM_{2.5}$.
Li et al., 2013 [6]	2004-2009	Stations operated by the Institute of Atmospheric Physics, Chinese Academy of Sciences in Beijing	Average over study period was 76 μg/m^3	Respiratory mortality and morbidity	Poisson regression	Average elevation of 0.69% and 1.32% in respiratory mortality and morbidity respectively with a 10 μg/m^3 increase in $PM_{2.5}$.
Zheng et al., 2015 [30]	2001 - 2012	Beijing central area	Average over study period was 100 μg/m^3	Mortality attributable to $PM_{2.5}$ by ischemic heart disease, cerebrovascular disease, chronic obstructive pulmonary disease, and lung cancer among the population older than 30 years and due to acute lower respiratory infection among the population less than 5 years old	Concentration-response functions	Total mortality due to $PM_{2.5}$ of 6,382 deaths per year in Beijing central area.
Liang et al., 2014 [29]	2008-2013	US Embassy site in Beijing	Annual means ranging from 85 to 105 μg/m^3	Influenza	Wavelet analysis	Ambient $PM_{2.5}$ concentrations were significantly associated with human influenza cases in Beijing.

Du and Li, 2016 [45]	January 2013	All 16 districts in Beijing (data obtained from the Beijing Municipal Environmental Monitoring Center)	Mean daily concentrations ranging from 98 to 228 μg/m^3	All cause mortality	Concentration-response	479 acute deaths from the continuous haze event in January 2013
Ferreri et al., 2018 [46]	January 11-13 2013 (extreme episode)	US Embassy site in Beijing	Daily $PM_{2.5}$ ≥ 350 μg/m^3 with peak daily average = 569 μg/m^3	All cause, cardiovascular, and respiratory emergency medical visits and respiratory outpatient visits	Several models including case-crossover	Risk increased during the episode for all-cause (relative risk 1.29), cardiovascular (1.55) and respiratory (1.33) emergency medical visits and respiratory outpatient visits (1.16).
Feng et al., 2016 [47]	2008 - 2014	US Embassy site in Beijing	Daily mean concentration = 101 μg/m^3	Influenza-like illness (ILI)	Inverse Gaussian generalized additive model	Strong positive correlation between $PM_{2.5}$ and ILI risk.