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Supplemental Information

Associations of particulate matter with dementia and mild cognitive impairment in China: A multicenter cross-sectional study

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Supplementary Material

Estimating concentrations of $PM_{2.5}$ and PM_{10}

a. Data downloading and processing

Daily concentrations of $PM_{2.5}$ and PM_{10} over China during 2005-2016 were estimated using MODIS AOD, meteorological data, land use information and other predictors. More details about the data downloading and processing were previously reported (Chen et al., 2018a; Chen et al., 2018b). Daily ground measurements of $PM_{2.5}$ and PM_{10} were obtained from 1479 stations of the China National Environmental Monitoring Center (CNEMC) from May 2014 to December 2016.

b. Model development

We used a machine learning method (random forests) for model development and prediction. This method is user-friendly, as there is no need to define the complex relationships between predictors (e.g., linear or nonlinear relationships and interactions) and the variable importance measures provided by random forests help user to identify important variables and noise variables (Hu et al., 2017). The final model is shown as following:

$$PM_{ij} = AOD_{ij} + TEMP_{ij} + RH_{ij} + BP_{ij} + WS_{ij} + NDVI + Urban\_cover + doy + \log(elev)$$

where $PM_{2.5ij}$ is the $PM_{2.5}$ or PM10 on day i at station j; AOD_{ij} is the combined AOD; *TEMP*, *RH*, *BP* and *WS* are mean temperature, relative humidity, barometric pressure and wind speed on day i, respectively; *NDVI* is the monthly average NDVI value; *Urban_cover* is the percentage of urban cover with a buffer radius of 10 km; *doy* is day of the year; *log(elev)* is the log transformed elevation.

c. Model validation and prediction

To evaluated the predictive ability of the final model, a 10-fold cross-validation (CV) was performed. The results are shown in Table S1.

Table S1. Results of 10-fold cross-validation for PM_1, $PM_{2.5}$, PM_{10} and NO_2

Pollutants	Daily model		Annual averages	
	CV R^2	RMSE	CV R^2	RMSE
$PM_{2.5}$	83%	18.1 μg/m^3	86%	6.9 μg/m^3
PM_{10}	78%	31.5 μg/m^3	81%	14.4 μg/m^3

The final random forests models were used to predict daily concentration of air pollutants in China. A 0.1-degree (≈ 10 km) grid (including around 96,103 grid cells) covering the entire China was created for data integration and prediction. Daily concentrations of$PM_{2.5}$ and PM_{10} were estimated for each grid cell during the study period. Predicted daily concentrations were aggregated into annual averages.

References:

Chen, G., Knibbs, L.D., Zhang, W., Li, S., Cao, W., Guo, J., Ren, H., Wang, B., Wang, H., Williams, G., Hamm, N.A.S., Guo, Y., 2018a. Estimating spatiotemporal distribution of PM1 concentrations in China with satellite remote sensing, meteorology, and land use information. Environmental Pollution 233, 1086-1094.

Chen, G., Li, S., Knibbs, L.D., Hamm, N.A.S., Cao, W., Li, T., Guo, J., Ren, H., Abramson, M.J., Guo, Y., 2018b. A machine learning method to estimate PM2.5 concentrations across China with remote sensing, meteorological and land use information. Science of the Total Environment 636, 52-60.

Hu, X., Belle, J.H., Meng, X., Wildani, A., Waller, L., Strickland, M., Liu, Y., 2017. Estimating PM2. 5 Concentrations in the Conterminous United States Using the Random Forest Approach. Environ Sci Technol.

Supplementary Tables and Figures

Table S2 . The comparison about the prevalence of dementia of Chinese male veterans (our study) and ordinary population

	Prevalence of dementia of ordinary population (%)	Number of male veterans	Expected number of dementia veterans	Observed number of dementia veterans
60-64	1.35	40	1	0
65-69	2.58	45	1	0
70-74	4.76	109	5	4
75-79	8.5	1830	156	94
80-84	14.63	3501	512	459
85-89	24.32	1246	303	295
90-94	39.03	179	70	60
>=95	60.47	20	12	9
Total	—	6970[a]	1060	921

[a]: The age data of 70 participants were missing. Data from 6,970 male veterans were included in the analysis after these missing data were excluded.

Table S3. A summary of included and excluded participants' exposure to $PM_{2.5}$ and PM_{10} (μg/m^3) during the three years prior to the survey.

Pollutants	Participants	n	Mean	Min	Percentiles			Max	SMD[a]
					25%	50%	75%		
$PM_{2.5}$									
	Included	7040	56.92	30.46	48.15	55.21	71.46	84.23	0.036
	Excluded	2636	56.44	30.46	47.04	54.89	66.13	84.23	
PM_{10}									
	Included	7040	102.71	53.38	83.68	100.16	128.34	143.14	0.094
	Excluded	2636	100.43	53.38	83.05	100.15	122.31	143.14	

a: standardised mean difference between included and excluded participants.

Table S4 (single-pollutant model**). The ORs (and 95%CIs) of MCI and dementia associated with per 10 μg/m^3 increase in PM.**

	MCI	Dementia
$PM_{2.5}$[a]	1.52 (1.39, 1.67)	1.27 (1.11, 1.46)
PM_{10}[a]	1.04 (1.00, 1.08)	1.13 (1.05, 1.21)
$PM_{10-2.5}$[a]	0.88 (0.84, 0.93)	1.12 (1.01, 1.23)

[a]: Adjusted for age, education years, smoking, drinking, family history of dementia, and history of NCDs. And city was modeled as random effect.

Table S5 (two-pollutant model**). The ORs (and 95%CIs) of MCI and dementia associated with per 10 μg/m^3 increase in PM and per 1 % increase in $PM_{2.5}$ / PM_{10} ratio.**

	MCI	Dementia
PM_{10}	1.19 (1.13, 1.25)	1.16 (1.07, 1.25)
$PM_{2.5}/PM_{10}$	2.13 (1.86, 2.44)	1.15 (0.96, 1.39)

Adjusted for age, education years, smoking, drinking, family history of dementia, and history of NCDs. And city was modeled as random effect.

Table S6. Male veterans participating in the CVCR Platform

Cities	Male veterans screened	Included in this study
Beijing	1234	1008
Shijiazhuang	1011	837
Dalian	881	567
Lanzhou	447	394
Yantai	457	341
Qingdao	589	492
Fuzhou	488	457
Chengdu	493	405
Guangzhou	530	423
Wuhan	147	111

Shanghai	720	416
Xi 'an	677	537
Tianjin	385	218
Baoding	201	155
Hohhot	189	175
Taiyuan	254	197
Guiyang	216	165
Harbin	177	142
Total	9096	7040

Table S7. The ORs (and 95%CIs) of MCI and dementia associated with personal hobbies

Personal hobbies	MCI		Dementia	
	OR (95%CI)	P	OR (95%CI)	P
Calligraphy	0.87 (0.74,1.03)	0.105	0.89 (0.66,1.20)	0.442
Painting	1.24 (0.98,1.56)	0.077	1.16 (0.75,1.81)	0.510
Photography	0.81 (0.65,1.02)	0.067	0.78 (0.50,1.24)	0.296
Collecting	0.79 (0.63,1.00)	**0.045**	0.65 (0.40,1.05)	0.077
Gardening	1.10 (0.96,1.25)	0.174	0.71 (0.57,0.90)	**0.005**
Pet keeping	1.17 (0.99,1.38)	0.069	1.14 (0.83,1.55)	0.420
Handicraft	0.66 (0.47,0.92)	**0.015**	0.61 (0.32,1.15)	0.125
Reading	0.71 (0.54,0.94)	**0.017**	0.41 (0.29,0.58)	**<0.001**
Keeping a diary	1.14 (0.94,1.38)	0.176	0.53 (0.34,0.82)	**0.005**
Writing articles	1.02 (0.87,1.20)	0.816	0.78 (0.57,1.07)	0.120
TV watching or listening to radio	1.24 (0.88,1.74)	0.213	0.79 (0.52,1.21)	0.279
Playing cards or mahjong	1.05 (0.92,1.20)	0.479	0.82 (0.65,1.04)	0.099

controlling for age, education years, smoking, drinking, family history of dementia, and history of NCDs.

Table S8. The ORs (and 95%CIs) of MCI and dementia associated with per 10 μg/m^3 increase in $PM_{2.5}$ or PM_{10}.

Models	$PM_{2.5}$ (ORs and 95%CIs)		PM_{10} (ORs and 95%CIs)	
	MCI	Dementia	MCI	Dementia
Model 1[a]	1.33 (1.23, 1.44)	1.10 (0.99, 1.22)	0.99 (0.97, 1.02)	1.03 (0.98, 1.09)
Model 2[b]	1.42 (1.31, 1.54)	1.20 (1.07, 1.34)	1.00 (0.97, 1.04)	1.08 (1.02, 1.15)
Model 3[c]	1.52 (1.39, 1.67)	1.27 (1.11, 1.46)	1.04 (1.00, 1.08)	1.13 (1.05, 1.21)
Model 4[d]	1.55 (1.42, 1.70)	1.28 (1.11, 1.47)	1.04 (1.00, 1.09)	1.11 (1.03, 1.19)

[a]: Model 1, a crude model including only one air pollutant; [b]:Model 2, an adjusted model controlling age, education years, smoking and drinking; [c]: Model 3, an adjusted model controlling age, education years, smoking, drinking, family history of dementia, and history of NCDs. [d]: an adjusted model controlling age, education years, smoking, drinking, family history of dementia, history of NCDs, and personal hobbies. In all models, city was modeled as random effect.

Table S9. Analysis of modification effects of several factors on the association between PM and MCI or dementia

Factors	$PM_{2.5}$ [ab]						PM_{10} (ORs and 95%CIs) [ab]					
	MCI			Dementia			MCI			Dementia		
	OR (95%CI)	z	p	OR (95%CI)	z	p	OR (95%CI)	z	p	OR (95%CI)	z	p
Age (years)												
< 80	1.57 (1.29, 1.90)	0.356	0.722	1.02 (0.69, 1.49)	-1.109	0.267	0.97 (0.92, 1.02)	-2.674	**0.008**	1.02 (0.84, 1.24)	-0.919	0.358
≥80	1.51 (1.36, 1.67)			1.28 (1.11, 1.47)			1.07 (1.01, 1.12)			1.13 (1.05, 1.22)		
Years of education												
≤9	1.62 (1.45, 1.81)	-2.105	**0.035**	1.34 (1.14, 1.57)	-1.537	0.124	1.03 (0.98, 1.08)	0.137	0.891	1.12 (1.04, 1.22)	-0.083	0.934
> 9	1.33 (1.15, 1.54)			1.06 (0.83, 1.37)			1.04 (0.96, 1.12)			1.12 (0.97, 1.28)		
Physical activities												
Yes	1.54 (1.40, 1.69)	0.509	0.611	1.37 (1.17, 1.61)	2.636	**0.008**	1.04 (0.99, 1.08)	-0.070	0.945	1.15 (1.06, 1.25)	1.089	0.276
No	1.42 (1.08, 1.87)			0.91 (0.70, 1.18)			1.04 (0.93, 1.17)			1.04 (0.90, 1.21)		
Social activities												
Yes	1.40 (1.22, 1.60)	-1.634	0.102	1.09 (0.85, 1.40)	-1.405	0.160	1.08 (1.01, 1.16)	1.837	0.066	1.13 (0.99, 1.29)	0.111	0.911
No	1.63 (1.45, 1.84)			1.35 (1.15, 1.58)			1.01 (0.97, 1.04)			1.12 (1.03, 1.22)		
Smoking												
Current[c]	1.47 (1.30, 1.66)	-0.041	0.968	1.07 (0.9, 1.28)	1.577	0.115	1.02 (0.97, 1.07)	-1.174	0.241	1.06 (0.97, 1.16)	1.004	0.316
Former[c]	1.61 (1.39, 1.86)	0.922	0.356	1.50 (1.20, 1.87)	2.290	0.022	1.08 (1.01, 1.16)	1.375	0.169	1.19 (1.07, 1.34)	1.592	0.111
Never	1.46 (1.07, 1.98)	-	-	1.73 (0.98, 3.04)	-	-	0.96 (0.87, 1.05)	-	-	1.23 (0.93, 1.62)	-	-
Drinking												
Current[d]	1.62 (1.19, 2.19)	0.144	0.885	1.66 (0.97, 2.86)	1.413	0.158	1.09 (0.95, 1.26)	1.118	0.264	1.31 (1.00, 1.71)	1.796	0.072
Former[d]	1.50 (1.26, 1.79)	-0.461	0.645	1.61 (1.18, 2.21)	2.051	**0.040**	1.08 (0.99, 1.18)	1.531	0.126	1.53 (1.28, 1.84)	4.019	**0.000**
Seldom[d]	1.41 (1.14, 1.74)	-0.909	0.364	1.19 (0.88, 1.60)	0.429	0.668	1.08 (0.97, 1.20)	1.210	0.226	1.05 (0.90, 1.24)	0.485	0.628
Never	1.58 (1.39, 1.80)	-	-	1.10 (0.91, 1.32)	-	-	1.00 (0.97, 1.04)	-	-	1.01 (0.92, 1.10)	-	-
Diabetes mellitus												
Yes	1.58 (1.34, 1.88)	0.447	0.655	1.27 (0.99, 1.62)	0.071	0.944	1.10 (1.02, 1.20)	1.742	0.081	1.07 (0.94, 1.21)	-0.985	0.325

No	1.51 (1.36, 1.68)			1.26 (1.07, 1.48)			1.01 (0.97, 1.06)			1.15 (1.06, 1.25)		
Hypertension												
Yes	1.48 (1.33, 1.65)	-0.738	0.460	1.26 (1.08, 1.48)	0.018	0.986	1.08 (1.02, 1.14)	2.265	**0.024**	1.16 (1.07, 1.26)	1.368	0.171
No	1.60 (1.35, 1.89)			1.26 (0.97, 1.63)			0.99 (0.95, 1.04)			1.05 (0.92, 1.19)		
Hyperlipidemia												
Yes	1.50 (1.31, 1.71)	-0.211	0.833	1.42 (1.14, 1.76)	1.491	0.136	1.19 (1.11, 1.28)	5.217	**0.000**	1.24 (1.10, 1.40)	2.271	**0.023**
No	1.53 (1.35, 1.72)			1.15 (0.97, 1.37)			0.97 (0.94, 1.00)			1.05 (0.96, 1.14)		
Cerebral infarction												
Yes	1.16 (1.01, 1.33)	-3.805	**0.000**	1.11 (0.90, 1.38)	-1.346	0.178	1.02 (0.96, 1.08)	-0.883	0.377	1.02 (0.92, 1.14)	-1.878	0.060
No	1.61 (1.46, 1.79)			1.34 (1.13, 1.58)			1.06 (1.01, 1.11)			1.16 (1.07, 1.27)		

[a] fully adjusted models controlling age, education years, smoking, drinking, family history of dementia, and history of NCDs. In all models, city was set as random effect factor. ORs and 95%CIs were associated with per 10 μg/m^3 increase in each pollutant. [b] the significance of difference in effect estimates between different subgroups was examined using a two-sample test. For smoking and drinking, the never smoke and never drink groups were set as the reference groups. * $p<0.05$ in the two-sample test. ** $p<0.01$ in the two-sample test.

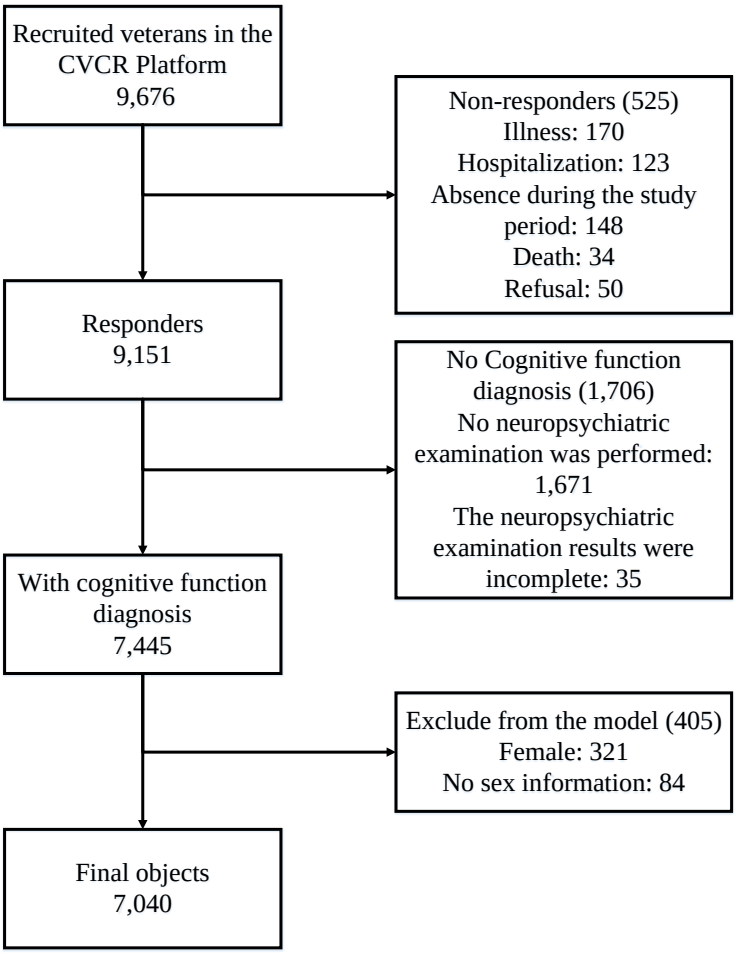

Figure S1. Flow chart of research object selection

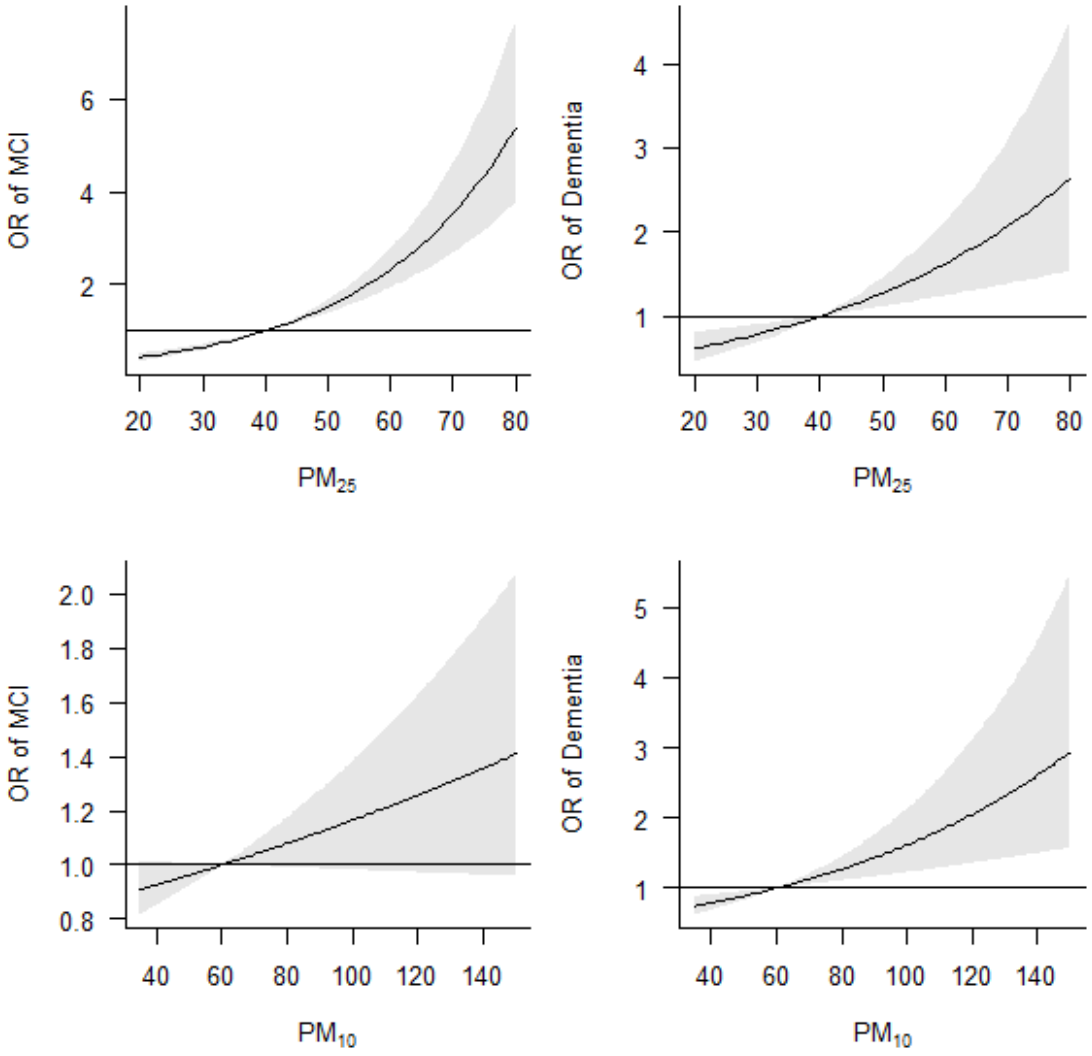

Figure S2. The non-linear associations between PM and MCI/dementia using natural cubic splines with three degrees of freedom on PM

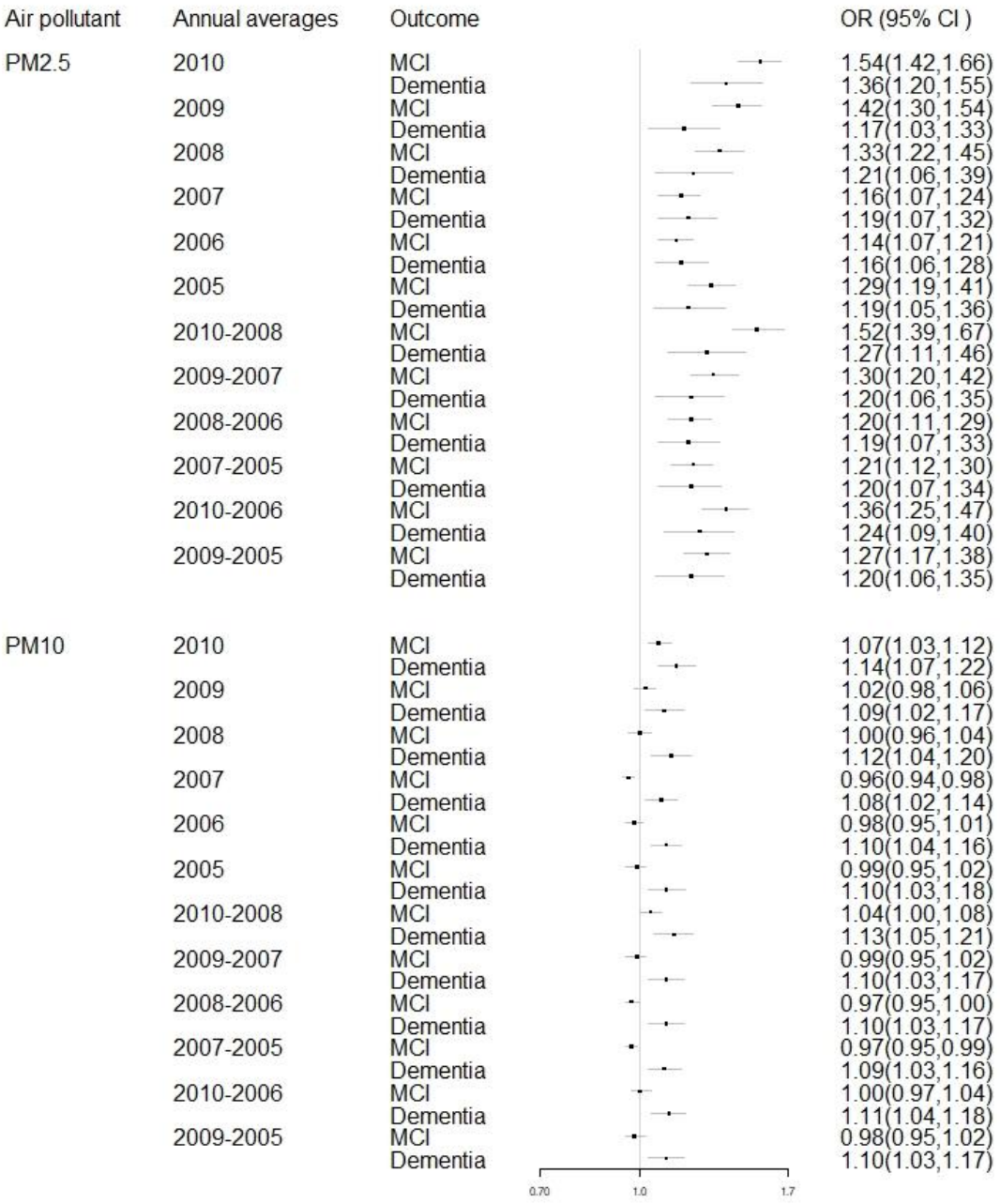

Figure S3. The sub-analyses for the evaluation of time scales for PM exposures