Supplemental Materials

Major Air Pollutants and Acute Risk of COPD: A Systematic Review and Meta-analysis

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Contents

S1 Detailed search strategy

1). MEDLINE and EMBASE

1. exp chronic obstructive pulmonary disease.mp. or COPD. mp. or Chronic Obstructive Pulmonary Disease.mp./
2. exp chronic obstructive airway disease. mp. or chronic obstructive lung disease.mp. or chronic airflow obstruction.mp. or pulmonary emphysema.mp. /
3. 1 or 2
4. [(air or atmosphere or atmospheric) adj (pollutant* or polluted or contamination or contaminated)].mp.(mp=ti, ab, sh, tn, hw, ot, dm, mf, ps, rs, ps, nm, ui, tx, ct, kw)/
5. exp ambience particulate matter.mp. or $PM_{2.5}$.mp or PM_{10}. mp./
6. exp ozone.mp. or Ozone.mp. or O_3.mp./
7. exp carbon monoxide.mp. or Carbon Monoxide .mp. or CO.mp./
8. exp sulphur dioxide.mp. or Sulphur Dioxide.mp. or SO_2. mp./
9. exp nitrogen dioxide.mp. or Nitrogen Dioxide.mp. or NO_2. mp./
10. 4 or 5 or 6 or 7 or 8 or 9
11. 3 and 10

2). Global Health, Web of Science, CINAHL, EBSCO, Cochrane Library

"chronic obstructive pulmonary disease" OR "COPD" OR "chronic obstructive airway disease" OR "Chronic Airflow obstructive" OR "Pulmonary Emphysema"

AND

"Air pollution" OR "ambient particular matter" OR "$PM_{2.5}$" OR "PM_{10}" OR "Ozone" OR "O_3" OR "carbon monoxide" OR "CO" OR "sulfur dioxide" OR "SO_2" OR "nitrogen dioxide" OR "NO_2" OR "Nitrogen oxides" OR "NO_X")

S2 Eligibility criteria

Inclusion Criteria

1. No language limitation
2. Full-length peer-reviewed studies with original data
3. Time-series studies and case-crossover studies
4. Had adequate sample sizes
5. Focus on the short-time air pollution exposure to the acute effects of COPD exacerbation, including mortality and hospitalization admission

Exclusion Criteria

1. Studies about case report/series, commentaries, letters, editorials, summaries, reviews
2. Focus on vivo or vitro or toxicological or mechanisms studies
3. Duplicate publications
4. Just conduct the long-term air pollution researches
5. The duration of study less than one year
6. No interested endpoints reported

Table S1 Contextual details of included studies

Study(year)	Lag exposure	Species	average concentration	lag-pattern	Model	Air pollutant concentration	Pollutant measurement quality score	Outcome measurements	Adjustments	Generalizability
Kloog *et al* 2014[1]	Lag01	$PM_{2.5}$	10.8±5.7	single-day	mono	mean	1	1	0	1
Meng *et al* 2013[2]	Lag01	BJ PM_{10}	138.9±87.0	single-day	both	mean	1	1	1	1
	Lag0-1	BJSO_2	41.4±43.8							
	Lag0-2	BJ NO_2	57.6±24.7							
	Lag0-3	SH PM_{10}	102±64.8							
		SH SO_2	44.7±24.2							
		SH NO_2	66.6±25.0							
		GZ PM_{10}	73.8±40.2							
		GZ SO_2	50.1±33.0							
		GZ NO_2	65.9±31.7							
		HK PM_{10}	51.6±22.3							
		HK SO_2	17.8±12.1							
		HK NO_2	58.7±20.1							
Tellez-Rojo *et al* 2000[3]	Lag1	PM_{10}	75.1±23.7	single-day	multi	both	1	1	1	1
	Lag2	O_3	134.5±33.4							
	Lag3	SO_2	0.02±0.005							
	Lag4	NO_2	0.038±0.01							
	Lag5									
Wordley *et al* 1997[4]	Lag1	PM_{10}	70.0	single-day	both	mean	1	1	1	1
	Lag2									
	Lag3									
Neuberger *et al* 2007[5]	Lag0-1	NO_2	31.0	mean days	mono	mean	1	1	1	0
	Lag0-7	SO_2	5.0							
		O_3	46.0							
		TSP	31.0							
		PM_{10}	30.0							

		$PM_{2.5}$	16.0							
Yorifuji *et al2014* [6]	Lag0-3	SPM	26.8±18.3	mean days	both	mean	1	1	0	1
		NO_2	17.1±8.1							
		SO_2	3.0±2.5							
		O_3	25.9±17.9							
		CO	0.6±0.3							
Shikowski *et al* 2014[7]	Lag2	$PM_{2.5}$	11.44	mean days	both	mean	0	1	1	1
Tao *et al* 2013[8]	Lag1-5	PM_{10}	196.6±169.5	single-day	both	mean	1	1	1	1
		SO_2	79.1±61.5							
		NO_2	45.9±29.3							
Moolgavkar *et al* 1997[9]	Lag0-3	PM_{10}	34.0	single-day	mono	mean	0	1	1	1
		SO_2	4.8							
		O_3	26.2							
		NO_2	16.3							
		CO	1.6							
Hinwood *et al* 2006[10]	Lag0-1	NO_2	9.6±4.8		mono	both	0	1	1	1
	Lag0-Lag01	O_3	27.7±7.4							
	Lag0-Lag02	BSP	0.2±0.13							
	Lag0-Lag03	CO	2.2±1.3							
		PM_{10}	20.6±7.7							
		$PM_{2.5}$	8.6±3.8							
Milutinovic *et al* 2009[11]	Lag0	BS	12.5±3.3	both	both	mean	1	1	1	1
	Lag1	SO_2	21.3±21.1							
	Lag2									
	Lag3									
	Lag0-1									
	Lag0-2									
	Lag0-3									

Arbex *et al* 2009[12]	Lag0	CO	2.7±1.2	both	mono	both	1	1	1	1
	Lag1	O_3	95.8±44.2							
	Lag2	NO_2	120.3±49.9							
	Lag3	SO_2	14.0±6.2							
	Lag4	PM_{10}	48.7±21.9							
	Lag5									
	Lag6									
Forastiere *et al* 2008[13]	Lag0-1	PM_{10}	40.0	mean days	mono	mean	1	1	1	1
Ko et al 2007[14]	Lag0	NO_2	51.2±21.8	both	both	mean	0	1	1	1
	Lag1	PM_{10}	50.1±23.9							
	Lag2	O_3	31.0±16.2							
	Lag3	SO_2	15.0±11.6							
	Lag4	$PM_{2.5}$	35.7±20.6							
	Lag5									
	Lag0-1									
	Lag0-2									
	Lag0-3									
	Lag0-4									
	Lag0-5									
Zanobetti *et al* 2000[15]	Lag0	PM_{10}	<50.0	single-day	both	mean	1	1	0	1
	Lag1									
	Lag2									
	Lag3									
	Lag4									
Morgan *et al* 1998[16]	Lag0	Particulates	0.3±0.2	both	both	both	1	1	1	1
	Lag1	O_3	25.0±13.0							
	Lag2	NO_2	15.0±6.0							
	Lag0-2									
Anderson *et al* 1997[17]	Lag1	SO_2	33.3			mean	0	1	1	1

	Lag1-3	NO_2	52.8	both	mono					
	Lag1-5	BS	21.6							
		TSP	85.5							
		O_3	46.8							
Peel *et al* 2005[18]	Lag0	PM_{10}	27.9±12.3	both	both	mean	1	1	1	1
	Lag1	NO_2	45.9±17.3							
	Lag2	CO	1.8±1.2							
		SO_2	16.5±17.1							
		O_3	55.6±23.8							
		$PM_{2.5}$	19.2±8.9							
Chen *et al* 2003[19]	Lag0	PM_{10}	13.3±6.1	both	both	mean	0	1	1	1
	Lag1	$PM_{10-2.5}$	5.6±3.6							
	Lag2	$PM_{2.5}$	7.7±3.7							
	Lag3	COH	0.3±0.1							
	Lag4	CO	0.7±0.3							
	Lag5	O_3	14.3±6.7							
	Lag6	NO_2	16.8±4.3							
	Lag7	SO_2	3.5±1.8							
	Lag0-3									
Wong *et al* 2002[20]	Lag0	NO_2	56.4±19.2	both	both	mean	0	1	1	1
	Lag1	PM_{10}	51.5±24.8							
	Lag2	O_3	33.9±23.2							
	Lag3	SO_2	16.7±11.6							
	Lag4									
	Lag5									
	Lag0-5									
	Lag0-3									
Tenias *et al* 2002[21]	Lag0	BS	38.8		both	both	0	0	1	1
	Lag1	NO_2	57.7							
	Lag2	O3	62.8							
	Lag3	SO_2	26.6							

	Lag4	CO	3.1							
	Lag5									
	Lag0-5									
	Lag0-3									
Yang *et al* 2004[22]	Lag0	CO	0.7±0.3	single-day		mean	1	1	1	1
	Lag1	O_3	14.1±6.6							
	Lag2	NO_2	17.0±4.5							
	Lag3	SO_2	3.8±2.1							
	Lag4	PM_{10}	14.0±6.2							
	Lag5									
	Lag6									
	Lag7									
Qiu *et al* 2012[23]	Lag0	PM_{10}	56.1±27.8	both	both	both	1	1	1	1
	Lag1	$PM_{2.5}$	39.4±20.7							
	Lag2	PMc	16.6±9,2							
	Lag3	NO_2	64.4±22.4							
	Lag4	SO_2	22.9±17.1							
	Lag5	O_3	31.1±24.3							
Stieb *et al* 2009[24]	Lag0	CO	0.7	both	mono	both	0	1	1	1
	Lag1	NO_2	18.4							
	Lag2	O_3	18.4							
	Lag0-2	PM_{10}	20.6							
		$PM_{2.5}$	8.2							
		SO_2	5.1							
Wong *et al* 1999[25]	Lag0	NO_2	51.4	both	multi	both	0	1	1	1
	Lag1	SO_2	17.1							
	Lag2	PM_{10}	45.0							
	Lag3	O_3	24.2							
	Lag4									
	Lag5									
	Lag0-3									

	Lag0-5									
Schouten *et al* 1996[26]	Lag0	A:O_3	69.0±33.0	both	mono	mean	1	1	1	1
	Lag1	SO_2	28.0±24.0							
	Lag0-1	NO_2	50.0±22.0							
	Lag0-2	BS	11.0±13.0							
		B:O_3	64.0±39.0							
		SO_2	40.0±29.0							
		NO_2	54.0±16.0							
		BS	26.0±18.0							
Fusco *et al* 2001[27]	Lag0	Particulates	66.4±21.2	single-day	both	mean	1	1	1	1
	Lag1	SO_2	9.1±5.8							
	Lag2	NO_2	86.7±16.2							
	Lag3	CO	3.6±1.2							
	Lag4	O_3	27.0±17.3							
Sauerzapf *et al* 2009[28]	Lag0-7	NO_2	22.0±8.5	mean days	mono	mean	1	0	1	1
		SO_2	6.9±10.9							
		CO	194.5±80.9							
		O_3	43.9±21.2							
		PM_{10}	19.9±8.5							
		NO_x	32.5±22.1							
Medina-Ramon *et al* 2005[29]	Lag0	O_3	40.1±15.3	both	mono	mean	0	1	1	1
	Lag1	PM_{10}	28.7±16.7							
	Lag0-1									
Janssen *et al* 2013[30]	Lag0	$PM_{2.5}$	16.3±11.1	both	both	mean	1	1	1	1
	Lag1	PM_{10}	23.9±12.9							
	Lag2	PMc	7.7±4.0							
	Lag3									
	Lag4									
	Lag0-									

Lin *et al* 2012[31]	Lag0	NO_2	33.0±43.9	mean days	both	both	1	1	1	1
	Lag1	O_x	48.8±21.8							
	Lag2	O_3	25.5±24.3							
	Lag3	PM_{10}	48.4±121.2							
	Lag4									
	Lag5									
Bateson *et al* 2004[32]	Lag1	PM_{10}	37.6±15.5	single-day	mono	both	0	1	1	1
Sunyer *et al* 2001[33]	Lag2	PM_{10}	13.5	mean days	mono	mean	0	0	1	0
		NO_2	8.5							
		O_3	10.5							
		CO	2.3							
Kan *et al* 2003[34]	Lag0-5	NO_2	91.14±15.3	mean days	mono	mean	0	1	0	1
		SO_2	42.49±6.1							
		PM_{10}	32.46±3.6							
Braga *et al* 2001[35]	Lag0	PM_{10}	33.1	both	mono	mean	0	1	1	1
	Lag0-1									
Schwartz *et al* 1992[36]	Lag2	TSP	77.2±22.4	mean	both	mean	0	1	1	1
		SO_2	21±3.8							
Fischer *et al* 2003[37]	Lag1 O3	PM_{10}	34±68.4	both	mono	mean	0	1	1	1
	Lag0-6	BS	10±30.4							
		O_3	47±**57.4**							
		NO_2	32±50.0							
		SO_2	10±62.7							
		CO	406±624.0							
Wong *et al* 2009[38]	Lag0-1	NO_2	58.7±20.0	mean		mean	0	1	1	1
		SO_2	17.8±12.1							
		PM_{10}	51.6±25.3							
		O_3	36.9±23.0							
Xu *et al* 2009[39]	Lag0-3	TSP	430.4±67.9	mean		mean	0	1	1	1
		SO_2	196.9±12.3							
Janssen *et al* 2002[40]	Lag1/2	PM_{10}	NA	mean	mono	mean	0	1	1	1

Dominici *et al* 2006[41]	Lag0	$PM_{2.5}$	13.4±0.5	both	mono					
	Lag1									
	Lag2									
Yang *et al* 2000[42]	Lag1	PM_{10}	36.6±27.9	single-day	mono	mean	0	1	1	1
Schwartz *et al* 1994[43]	Lag1	PM_{10}	24±3.3	single-day	mono	both	0	1	1	1
		O_3	41±7.6							
Schwartz(s) et al[44] 1994	Lag0-2	PM_{10}	25±4.3	both	mono	both	0	1	1	1
Schwartz(t) et al[45] 1994	Lag0-2	PM_{10}	48±8.2	mean	mono	both	0	1	1	1
		O_3	21±4.1							
Sunyer *et al* 1993[46]	Lag1	SO_2	49±7.9	both	multi	mean	1	1	1	1
	Lag0-2	BS	29±5.1							
Lippmann *et al* 2000[47]	Lag1	TSP	68.7±9.4		multi	mean	1	1	1	1
	Lag2	PM_{10}	45.4±7.9							
	Lag0-1	SO_2	9.8±1.7							
	Lag0-2	NO_2	23.3±3.1							
	Lag0-3	O_3	20.9±4.0							
		CO	0.9±0.1							
Dab *et al* 1996[48]	Lag0	SO_2	29.7	both	both	both	1	1	1	1
	Lag1	BS	31.9							
	Lag2	PM_{13}	50.8							
	Lag0-4	NO_2	45.0							
		O_3	27.7							
Leitte *et al* 2009[49]	Lag0-7	SO_2	11.8±3.8	both	multi	both	1	1	1	1
		NO_2	4.7±1.6							
		TSP	123.5±44.1							
Pande *et al* 2002[50]	Lag1	TSP	417.5±151.0	mean	both	mean	1	1	1	1
		CO	5138.0±2651.0							
		NOx	65.0±25.0							
		SO_2	23.0±11.5							

Cirera *et al* 2011[51]	Lag0-4	TSP	52.0±18.0	single-day	both	mean	0	1	1	1
		SO_2	32.0±13.0							
		NO_2	51.0±23.0							
		O_3	80.0±18.0							
Yang *et al* 2007[52]	Lag0-2	PM_{10}	49.0±6.7	mean	both	mean	1	1	0	1
		SO_2	4.3±0.7							
		NO_2	30.8±2.6							
		CO	1.3±0.1							
		O_3	20.5±2.9							
Lee *et al* 2007[53]	Lag0-2	PM_{10}	76.6±15.9	mean	both	mean	1	1	0	1
		SO_2	9.5±1.5							
		NO_2	27.2±4.3							
		CO	0.8±0.07							
		O_3	26.3±5.2							
Peacok *et al*2010[54]	Lag0-1	NO_2	51.4±15.8	both	both	both	o	1	1	1
		O_3	15.5±10.7							
		SO_2	7.5±6.3							
		PM_{10}	37.7±17.4							
		BS	10.1±9.7							
Zhang *et al* 2013[55]	Lag0	NO_2	17.6±8.9	both	both	mean	0	1	1	1
	Lag1	SO_2	2.0±7.1							
	Lag2	PM_{10}	8.0±11.6							
	Lag3									
	Lag4									
	Lag5									
	Lag0-5									
Cho *et al* 2013[56]	Lag0	SO_2	2.3	single-day	both	both	0	1	1	1
	Lag1	PM_{10}	36.7							
	Lag2	O_3	10.0							
	Lag3	NO_2	12.0							
	Lag0-1	CO	0.2							

	Lag0-2									
	Lag0-3									
Tian *et al* 2014[57]	Lag0	CO	0.6±0.2	both	both	mean	1	1	1	1
	Lag1	$PM_{2.5}$	0.8±0.4							
	Lag2	NO_2	40.9±18.2							
	Lag0-2									
To *et al* 2015[58]	Lag0	NO_2	24.4±12.4	both	mono	mean	1	1	1	1
	Lag2	O_3	39.6±14.2							
	Lag1	$PM_{2.5}$	13.9±9.5							
Cai *et al* 2015[59]	Lag0	CO	1.3±0.5	both	both	mean	1	1	1	1
	Lag1	PM_{10}	92.0±55.0							
	Lag2	SO_2	53.0±29.0							
	Lag3	NO_2	61.0±23.0							
	Lag4									
	Lag0-4									

Table S2 Sensitivity analysis of included studies (Before & after removing studies with increased risk of bias)

Pollutants	RR	LL	UL
Nitrogen dioxide			
Overall estimate	1.04	1.02	1.06
Estimate excluding studies at risk of bias	1.03	1.02	1.04
Carbon monoxide			
Overall estimate	1.01	1.00	1.01
Estimate excluding studies at risk of bias	1.00	1.00	1.01
Sulphur dioxide			
Overall estimate	1.01	1.00	1.01
Estimate excluding studies at risk of bias	1.01	1.00	1.01
Ozone			
Overall estimate	1.01	1.01	1.02
Estimate excluding studies at risk of bias	1.02	1.01	1.03
$PM_{2.5}$			
Overall estimate	1.01	1.00	1.01
Estimate excluding studies at risk of bias	1.02	1.02	1.03
PM_{10}			
Overall estimate	1.01	1.01	1.01
Estimate excluding studies at risk of bias	1.02	1.02	1.02

Table S3 Results of subgroup analysis

Subgroup Characteristics	Gaseous Pollutants				Particulate Pollutants	
	SO_2 (10 μg/m³)	**NO_2 (10 μg/m³)**	**O_3 (10 μg/m³)**	**CO (100μg/m³)**	**$PM_{2.5}$ (10 μg/m³)**	**PM_{10} (10 μg/m³)**
Lag Subgroup						
Study number	5	8	6	6	4	7
Lag exposure, d	0	0	3	1	0	3
Heterogeneity, I^2 (%)	91.5	94.9	5.9	61.4	76.8	55.8
RR (95%CI)	1.007 (1.003,1.011)	1.030 (1.026,1.033)	1.013 (1.010,1.016)	1.000 (0.987,1.003)	1.002 (1.001,1.005)	1.009 (1.006,1.011)
Egger's test, *P*	0.312	0.780	0.351	0.410	0.362	0.127
Quality Subgroup						
*Study number	28	27	28	13	15	34
Heterogeneity, I^2	76.5	98.1	63.0	92.9	91.1	83.8
RR (95%CI)	1.000 (1.000,1.000)	1.017 (1.015,1.019)	0.958 (0.958,0.958)	1.006 (1.002,1.011)	1.007 (1.005,1.009)	1.008 (1.007,1.009)
Egger's test, *P*	0.007	0.147	0.001	0.163	0.447	0.001
Property Subgroup						
^Category (number)	Age≥65(10)	Mortality(7)	Age≥65(12)	Mortality(2)	Mortality(2)	Non-Asian(10)
Heterogeneity, I^2	62.4	21.9	27.1	2.7	47.2	66.3
RR (95%CI)	1.004 (0.999,1.008)	1.017 (1.012,1.021)	1.009 (1.006,1.011)	1.012 (0.999,1.026)	1.025 (1.007,1.043)	1.006 (1.005,1.007)
Egger's test, *P*	0.129	0.881	0.315	NA	NA	0.001

- Include good quality and intermediate quality

^ The category that reduced the heterogeneities most significantly

Table S4 Meta-regression analyses of the studies

A: Carbon Monoxide

Stratified study	No. of studies	Meta-regression			Heterogeneity	
		Coef.	Adj R^2 (%)	*p*-value	I^2 (%)	*p*-value
Study design		-0.166	14.52	0.178		
Time-series	8				75.5	0.001
Case crossover	7				98.5	0.001
Location		-0.271	38.49	0.056		
Asia	5				90.6	0.001
Non-Asia	10				70.8	0.001
COPD Subtype		0.066	-10.90	0.729		
Mortality	2				2.70	0.311
Hospital Admission	13				78.5	0.001
Age		-0.125	-13.83	0.502		
>=65	12				81.2	0.005
All	3				77.4	0.001

B: Sulfur dioxide

Stratified study	No. of studies	Meta-regression			Heterogeneity	
		Coef.	Adj R^2 (%)	*p*-value	I^2 (%)	*p*-value
Study design		-0.137	8.06	0.348		
Time-series	24				73.3	0.001
Case crossover	7				76.3	0.001
Location		-0.005	-3.46	0.564		
Asia	14				87.6	0.001
Non-Asia	17				64.0	0.001
COPD Subtype		-0.004	-1.28	0.674		
Mortality	6				90.9	0.001
Hospital Admission	25				74.7	0.001
Age		-0.001	-10.68	0.955		
>=65	25				62.4	0.004
All	8				74.7	0.001

C: Nitrogen dioxide

Stratified study	No. of studies	Meta-regression			Heterogeneity	
		Coef.	Adj R^2 (%)	*p*-value	I^2 (%)	*p*-value
Study design		-0.166	26.95	0.014		
Time-series	24				73.3	0.001
Case crossover	9				76.3	0.001
Location		0.038	-1.92	0.419		
Asia	16				87.6	0.001
Non-Asia	17				64.0	0.001
COPD Subtype		0.063	-1.72	0.405		
Mortality	7				21.9	0.311
Hospital Admission	27				74.7	0.001
Age		0.062	-3.82	0.470		
>=65	25				62.4	0.004
All	8				83.3	0.001

D: Ozone

Stratified study	No. of studies	Meta-regression			Heterogeneity	
		Coef.	Adj R^2 (%)	*p*-value	I^2 (%)	*p*-value
Study design		-0.072	13.31	0.017		
Time-series	24				90.0	0.001
Case crossover	10				84.0	0.001
Location		-0.047	4.87	0.094		
Asia	5				83.6	0.001
Non-Asia	10				88.4	0.001
COPD Subtype		0.030	-2.88	0.399		
Mortality	5				74.8	0.311
Hospital Admission	29				78.8	0.001
Age		0.0124	-3.15	0.685		
>=65	23				27.1	0.179
All	11				78.4	0.001

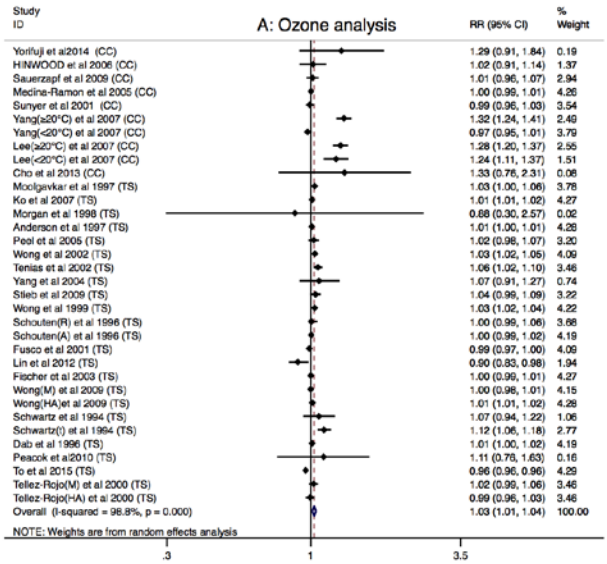
E: $PM_{2.5}$

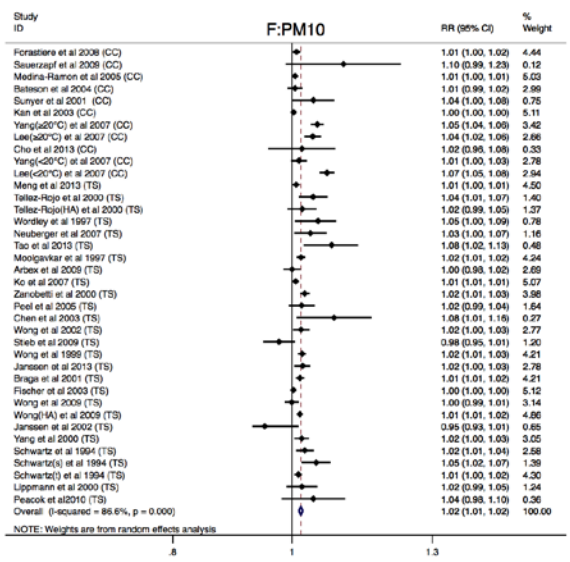
Stratified study	No. of studies	Meta-regression			Heterogeneity	
		Coef.	Adj R^2 (%)	*p*-value	I^2 (%)	*p*-value
Study design		-0.024	4.11	0.300		
Time-series	8				78.6	0.001
Case crossover	7				79.5	0.001
Location		-0.011	19.32	0.137		
Asia	5				82.7	0.001
Non-Asia	10				76.3	0.001
COPD Subtype		-0.016	-6.73	0.602		
Mortality	2				47.2	0.165
Hospital Admission	13				80.7	0.001
Age		0.022	-5.43	0.344		
>=65	12				66.3	0.018
All	3				80.2	0.001

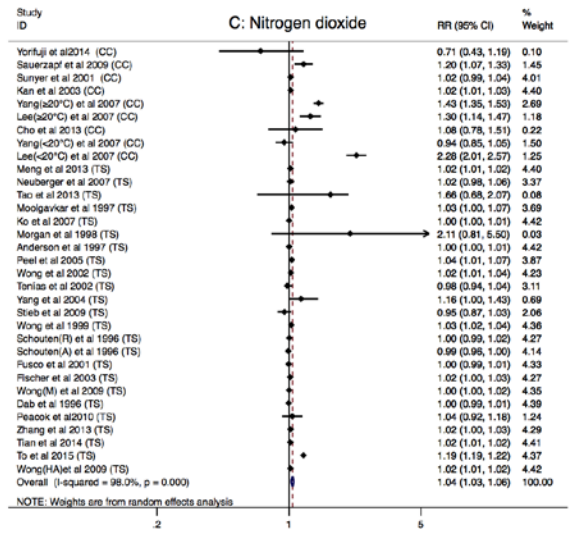
F: PM_{10}

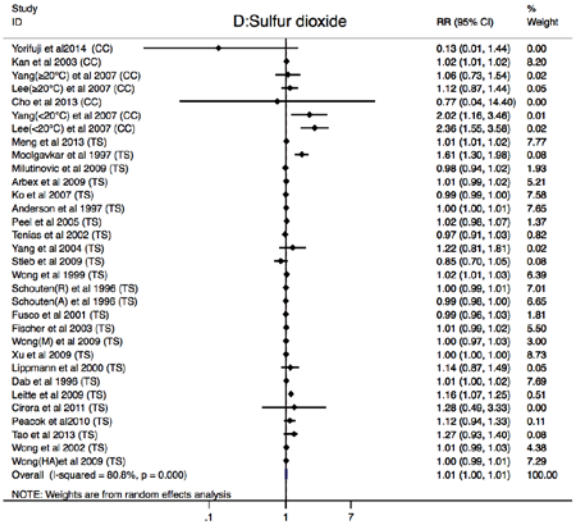
Stratified study	No. of studies	Meta-regression			Heterogeneity	
		Coef.	Adj R^2 (%)	*p*-value	I^2 (%)	*p*-value
Study design		-0.008	0.99	0.224		
Time-series	27				78.6	0.001
Case crossover	11				73.1	0.001
Location		-0.004	-2.14	0.540		
Asia	13				72.7	0.001
Non-Asia	25				66.3	0.001
COPD Subtype		0.006	5.26	0.328		
Mortality	14				69.5	0.001
Hospital Admission	24				76.7	0.001
Age		0.001	-4.61	0.943		
>=65	15				69.2	0.001
All	26				87.1	0.001

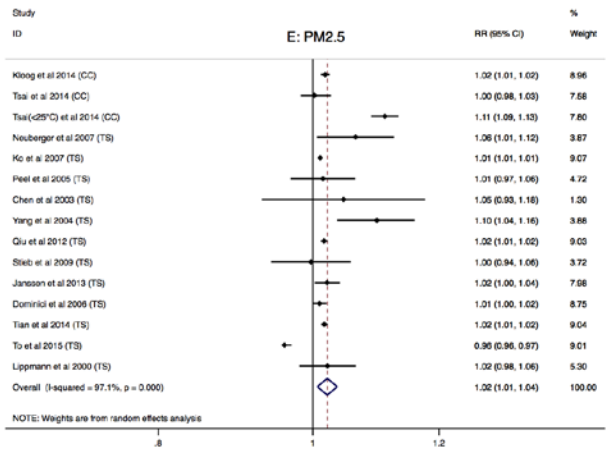
Figure S1


A: Ozone analysis
Study ID
RR (95% CI)
% Weight
Yorifuji et al2014 (CC) 1.29 (0.91, 1.84) 0.19
HINWOOD et al 2006 (CC) 1.02 (0.91, 1.14) 1.37
Sauerzapf et al 2009 (CC) 1.01 (0.96, 1.07) 2.94
Medina-Ramon et al 2005 (CC) 1.00 (0.98, 1.01) 4.26
Sunyer et al 2001 (CC) 0.99 (0.96, 1.03) 3.54
Yang(≥20°C) et al 2007 (CC) 1.32 (1.24, 1.41) 2.49
Yang(<20°C) et al 2007 (CC) 0.97 (0.95, 1.01) 3.79
Lee(≥20°C) et al 2007 (CC) 1.28 (1.20, 1.37) 2.55
Lee(<20°C) et al 2007 (CC) 1.24 (1.11, 1.37) 1.51
Cho et al 2013 (CC) 1.33 (0.76, 2.31) 0.08
Moolgavkar et al 1997 (TS) 1.03 (1.00, 1.06) 3.78
Ko et al 2007 (TS) 1.01 (1.01, 1.02) 4.27
Morgan et al 1998 (TS) 0.88 (0.30, 2.57) 0.02
Anderson et al 1997 (TS) 1.01 (1.00, 1.01) 4.26
Peel et al 2005 (TS) 1.02 (0.98, 1.07) 3.20
Wong et al 2002 (TS) 1.03 (1.02, 1.05) 4.09
Tenias et al 2002 (TS) 1.06 (1.02, 1.10) 3.46
Yang et al 2004 (TS) 1.07 (0.91, 1.27) 0.74
Stieb et al 2009 (TS) 1.04 (0.99, 1.09) 3.22
Wong et al 1999 (TS) 1.03 (1.02, 1.04) 4.22
Schouten(R) et al 1996 (TS) 1.00 (0.99, 1.06) 3.68
Schouten(A) et al 1996 (TS) 1.00 (0.99, 1.02) 4.19
Fusco et al 2001 (TS) 0.99 (0.97, 1.00) 4.09
Lin et al 2012 (TS) 0.90 (0.83, 0.98) 1.94
Fischer et al 2003 (TS) 1.00 (0.99, 1.01) 4.27
Wong(M) et al 2009 (TS) 1.00 (0.98, 1.01) 4.15
Wong(HA)et al 2009 (TS) 1.01 (1.01, 1.02) 4.28
Schwartz et al 1994 (TS) 1.07 (0.94, 1.22) 1.06
Schwartz(t) et al 1994 (TS) 1.12 (1.06, 1.18) 2.77
Dab et al 1996 (TS) 1.01 (1.00, 1.02) 4.19
Peacok et al2010 (TS) 1.11 (0.76, 1.63) 0.16
To et al 2015 (TS) 0.96 (0.96, 0.96) 4.29
Tellez-Rojo(M) et al 2000 (TS) 1.02 (0.99, 1.06) 3.46
Tellez-Rojo(HA) et al 2000 (TS) 0.99 (0.96, 1.03) 3.46
Overall (I-squared = 98.8%, p = 0.000) 1.03 (1.01, 1.04) 100.00
NOTE: Weights are from random effects analysis
.3
1
3.5


F:PM10
Study ID
RR (95% CI)
% Weight
Forastiere et al 2008 (CC) 1.01 (1.00, 1.02) 4.44
Sauerzapf et al 2009 (CC) 1.10 (0.99, 1.23) 0.12
Medina-Ramon et al 2005 (CC) 1.01 (1.00, 1.01) 5.03
Bateson et al 2004 (CC) 1.01 (0.99, 1.02) 2.99
Sunyer et al 2001 (CC) 1.04 (1.00, 1.08) 0.75
Kan et al 2003 (CC) 1.00 (1.00, 1.00) 5.11
Yang(≥20°C) et al 2007 (CC) 1.05 (1.04, 1.06) 3.42
Lee(≥20°C) et al 2007 (CC) 1.04 (1.02, 1.06) 2.66
Cho et al 2013 (CC) 1.02 (0.96, 1.08) 0.33
Yang(<20°C) et al 2007 (CC) 1.01 (1.00, 1.03) 2.78
Lee(<20°C) et al 2007 (CC) 1.07 (1.05, 1.08) 2.94
Meng et al 2013 (TS) 1.01 (1.00, 1.01) 4.50
Tellez-Rojo et al 2000 (TS) 1.04 (1.01, 1.07) 1.40
Tellez-Rojo(HA) et al 2000 (TS) 1.02 (0.99, 1.05) 1.37
Wordley et al 1997 (TS) 1.05 (1.00, 1.09) 0.78
Neuberger et al 2007 (TS) 1.03 (1.00, 1.07) 1.16
Tao et al 2013 (TS) 1.08 (1.02, 1.13) 0.48
Moolgavkar et al 1997 (TS) 1.02 (1.01, 1.02) 4.24
Arbex et al 2009 (TS) 1.00 (0.93, 1.02) 2.69
Ko et al 2007 (TS) 1.01 (1.01, 1.01) 5.07
Zanobetti et al 2000 (TS) 1.02 (1.01, 1.03) 3.98
Peel et al 2005 (TS) 1.02 (0.99, 1.04) 1.64
Chen et al 2003 (TS) 1.08 (1.01, 1.16) 0.27
Wong et al 2002 (TS) 1.02 (1.00, 1.03) 2.77
Stieb et al 2009 (TS) 0.98 (0.95, 1.01) 1.20
Wong et al 1999 (TS) 1.02 (1.01, 1.03) 4.21
Jansson et al 2013 (TS) 1.02 (1.00, 1.03) 2.78
Braga et al 2001 (TS) 1.01 (1.01, 1.02) 4.21
Fischer et al 2003 (TS) 1.00 (1.00, 1.00) 5.12
Wong et al 2009 (TS) 1.00 (0.99, 1.01) 3.14
Wong(HA) et al 2009 (TS) 1.01 (1.01, 1.02) 4.86
Jansson et al 2002 (TS) 0.95 (0.93, 1.01) 0.65
Yang et al 2000 (TS) 1.02 (1.00, 1.03) 3.05
Schwartz et al 1994 (TS) 1.02 (1.01, 1.04) 2.58
Schwartz(s) et al 1994 (TS) 1.05 (1.02, 1.07) 1.39
Schwartz(t) et al 1994 (TS) 1.01 (1.00, 1.02) 4.30
Lippmann et al 2000 (TS) 1.02 (0.99, 1.05) 1.24
Peacok et al2010 (TS) 1.04 (0.98, 1.10) 0.36
Overall (I-squared = 86.6%, p = 0.000) 1.02 (1.01, 1.02) 100.00
NOTE: Weights are from random effects analysis
.8
1
1.3


C: Nitrogen dioxide
Study ID
RR (95% CI)
% Weight
Yorifuji et al2014 (CC) 0.71 (0.43, 1.19) 0.10
Sauerzapf et al 2009 (CC) 1.20 (1.07, 1.33) 1.45
Sunyer et al 2001 (CC) 1.02 (0.99, 1.04) 4.01
Kan et al 2003 (CC) 1.02 (1.01, 1.03) 4.40
Yang(≥20°C) et al 2007 (CC) 1.43 (1.35, 1.53) 2.69
Lee(≥20°C) et al 2007 (CC) 1.30 (1.14, 1.47) 1.18
Cho et al 2013 (CC) 1.08 (0.78, 1.51) 0.22
Yang(<20°C) et al 2007 (CC) 0.94 (0.85, 1.05) 1.50
Lee(<20°C) et al 2007 (CC) 2.28 (2.01, 2.57) 1.25
Meng et al 2013 (TS) 1.02 (1.01, 1.02) 4.40
Neuberger et al 2007 (TS) 1.02 (0.98, 1.06) 3.37
Tao et al 2013 (TS) 1.66 (0.68, 2.07) 0.08
Moolgavkar et al 1997 (TS) 1.03 (1.00, 1.07) 3.69
Ko et al 2007 (TS) 1.00 (1.00, 1.01) 4.42
Morgan et al 1998 (TS) 2.11 (0.81, 5.50) 0.03
Anderson et al 1997 (TS) 1.00 (1.00, 1.01) 4.42
Peel et al 2005 (TS) 1.04 (1.01, 1.07) 3.87
Wong et al 2002 (TS) 1.02 (1.01, 1.04) 4.23
Tenias et al 2002 (TS) 0.98 (0.94, 1.04) 3.11
Yang et al 2004 (TS) 1.16 (1.00, 1.43) 0.69
Stieb et al 2009 (TS) 0.95 (0.87, 1.03) 2.06
Wong et al 1999 (TS) 1.03 (1.02, 1.04) 4.36
Schouten(R) et al 1996 (TS) 1.00 (0.99, 1.02) 4.27
Schouten(A) et al 1996 (TS) 0.99 (0.98, 1.00) 4.14
Fusco et al 2001 (TS) 1.00 (0.99, 1.01) 4.33
Fischer et al 2003 (TS) 1.02 (1.00, 1.03) 4.27
Wong(M) et al 2009 (TS) 1.00 (1.00, 1.02) 4.35
Dab et al 1996 (TS) 1.00 (0.99, 1.01) 4.39
Peacok et al2010 (TS) 1.04 (0.92, 1.18) 1.24
Zhang et al 2013 (TS) 1.02 (1.00, 1.03) 4.29
Tian et al 2014 (TS) 1.02 (1.01, 1.02) 4.41
To et al 2015 (TS) 1.19 (1.19, 1.22) 4.37
Wong(HA)et al 2009 (TS) 1.02 (1.01, 1.02) 4.42
Overall (I-squared = 98.0%, p = 0.000) 1.04 (1.03, 1.06) 100.00
NOTE: Weights are from random effects analysis
.2
1
5


D:Sulfur dioxide
Study ID
RR (95% CI)
% Weight
Yorifuji et al2014 (CC) 0.13 (0.01, 1.44) 0.00
Kan et al 2003 (CC) 1.02 (1.01, 1.02) 8.20
Yang(≥20°C) et al 2007 (CC) 1.06 (0.73, 1.54) 0.02
Lee(≥20°C) et al 2007 (CC) 1.12 (0.87, 1.44) 0.05
Cho et al 2013 (CC) 0.77 (0.04, 14.40) 0.00
Yang(<20°C) et al 2007 (CC) 2.02 (1.16, 3.46) 0.01
Lee(<20°C) et al 2007 (CC) 2.36 (1.55, 3.58) 0.02
Meng et al 2013 (TS) 1.01 (1.01, 1.02) 7.77
Moolgavkar et al 1997 (TS) 1.61 (1.30, 1.98) 0.08
Milutinovic et al 2009 (TS) 0.98 (0.94, 1.02) 1.93
Arbex et al 2009 (TS) 1.01 (0.99, 1.02) 5.21
Ko et al 2007 (TS) 0.99 (0.99, 1.00) 7.58
Anderson et al 1997 (TS) 1.00 (1.00, 1.01) 7.65
Peel et al 2005 (TS) 1.02 (0.98, 1.07) 1.37
Tenias et al 2002 (TS) 0.97 (0.91, 1.03) 0.82
Yang et al 2004 (TS) 1.22 (0.81, 1.81) 0.02
Stieb et al 2009 (TS) 0.85 (0.70, 1.05) 0.08
Wong et al 1999 (TS) 1.02 (1.01, 1.03) 6.39
Schouten(R) et al 1996 (TS) 1.00 (0.99, 1.01) 7.01
Schouten(A) et al 1996 (TS) 0.99 (0.98, 1.00) 6.65
Fusco et al 2001 (TS) 0.99 (0.96, 1.03) 1.81
Fischer et al 2003 (TS) 1.01 (0.99, 1.02) 5.50
Wong(M) et al 2009 (TS) 1.00 (0.97, 1.03) 3.00
Xu et al 2009 (TS) 1.00 (1.00, 1.00) 8.73
Lippmann et al 2000 (TS) 1.14 (0.97, 1.49) 0.05
Dab et al 1996 (TS) 1.01 (1.00, 1.02) 7.69
Leitte et al 2009 (TS) 1.16 (1.07, 1.25) 0.51
Cirera et al 2011 (TS) 1.28 (0.49, 3.33) 0.00
Peacok et al2010 (TS) 1.12 (0.94, 1.33) 0.11
Tao et al 2013 (TS) 1.27 (0.93, 1.40) 0.08
Wong et al 2002 (TS) 1.01 (0.99, 1.03) 4.38
Wong(HA)et al 2009 (TS) 1.00 (0.99, 1.01) 7.29
Overall (I-squared = 80.8%, p = 0.000) 1.01 (1.00, 1.01) 100.00
NOTE: Weights are from random effects analysis
.1
1
7


E: PM2.5
Study ID
RR (95% CI)
% Weight
Kloog et al 2014 (CC) 1.02 (1.01, 1.02) 8.96
Tsai et al 2014 (CC) 1.00 (0.98, 1.03) 7.58
Tsai(<25°C) et al 2014 (CC) 1.11 (1.09, 1.13) 7.80
Neuberger et al 2007 (TS) 1.06 (1.01, 1.12) 3.87
Ko et al 2007 (TS) 1.01 (1.01, 1.01) 9.07
Peel et al 2005 (TS) 1.01 (0.97, 1.06) 4.72
Chen et al 2003 (TS) 1.05 (0.93, 1.18) 1.30
Yang et al 2004 (TS) 1.10 (1.04, 1.16) 3.88
Qiu et al 2012 (TS) 1.02 (1.01, 1.02) 9.03
Stieb et al 2009 (TS) 1.00 (0.94, 1.06) 3.72
Jansson et al 2013 (TS) 1.02 (1.00, 1.04) 7.98
Dominici et al 2006 (TS) 1.01 (1.00, 1.02) 8.75
Tian et al 2014 (TS) 1.02 (1.01, 1.02) 9.04
To et al 2015 (TS) 0.96 (0.96, 0.97) 9.01
Lippmann et al 2000 (TS) 1.02 (0.98, 1.06) 5.30
Overall (I-squared = 97.1%, p = 0.000) 1.02 (1.01, 1.04) 100.00
NOTE: Weights are from random effects analysis
.8
1
1.2

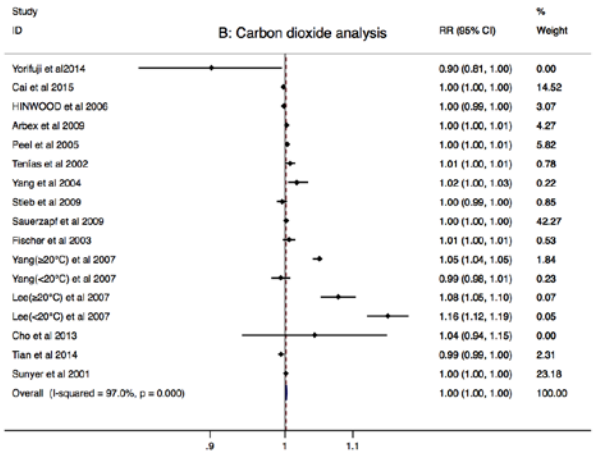
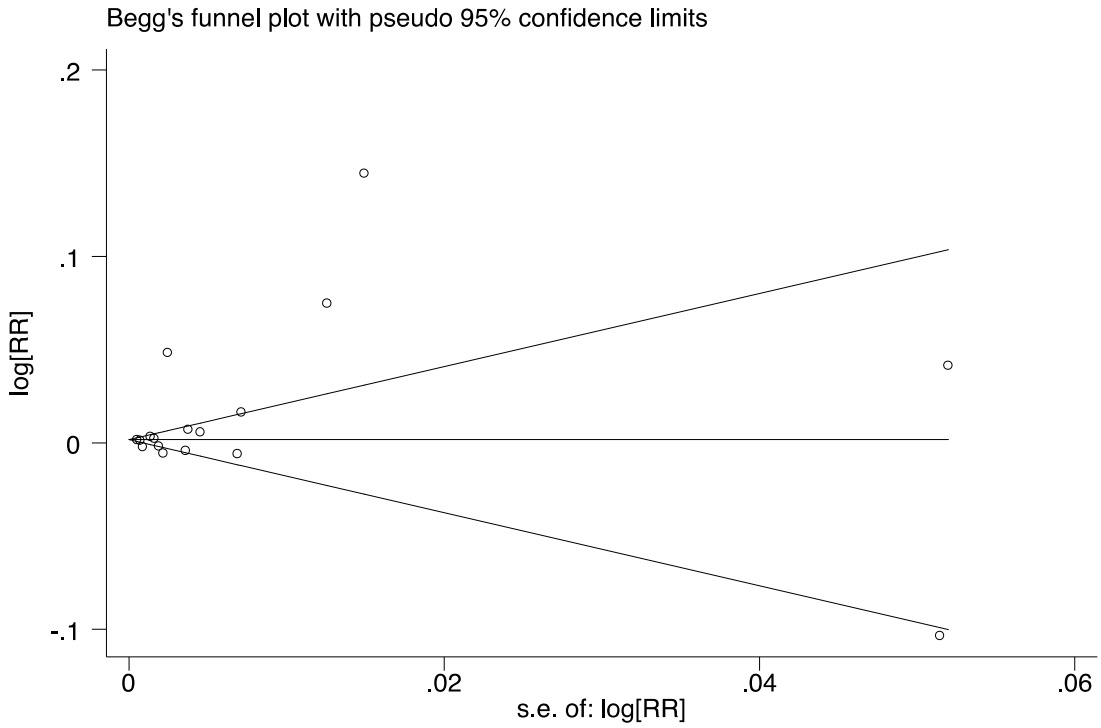
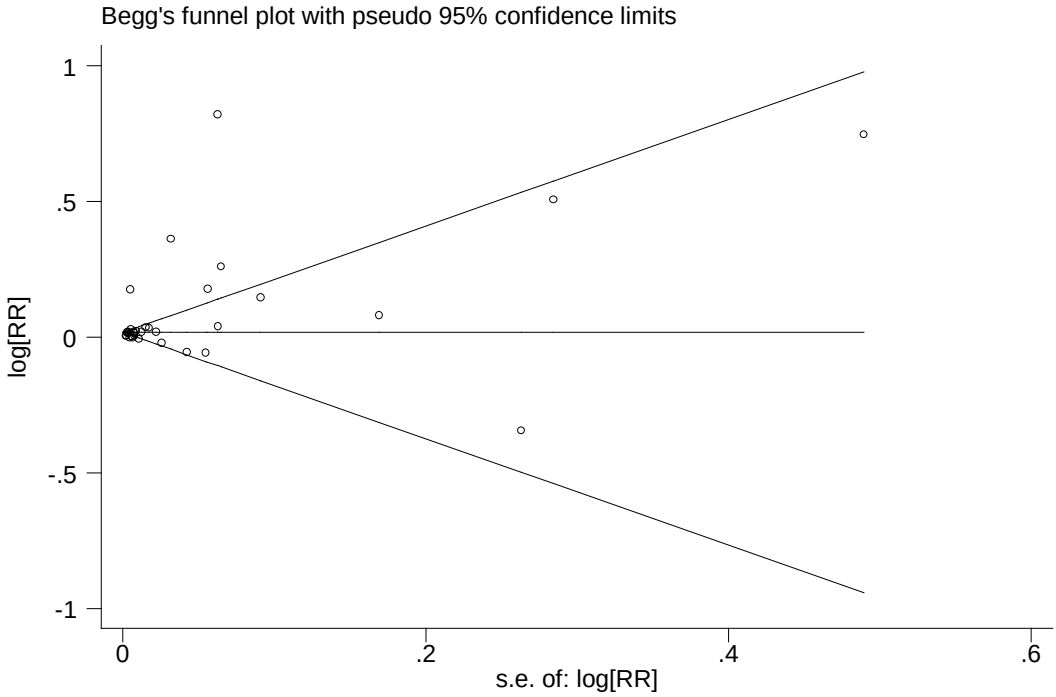

B: Carbon dioxide analysis
Study ID
RR (95% CI)
% Weight
Yorifuji et al2014 0.90 (0.81, 1.00) 0.00
Cai et al 2015 1.00 (1.00, 1.00) 14.52
HINWOOD et al 2006 1.00 (0.99, 1.00) 3.07
Arbex et al 2009 1.00 (1.00, 1.01) 4.27
Peel et al 2005 1.00 (1.00, 1.01) 5.82
Tenias et al 2002 1.01 (1.00, 1.01) 0.78
Yang et al 2004 1.02 (1.00, 1.03) 0.22
Stieb et al 2009 1.00 (0.99, 1.00) 0.85
Sauerzapf et al 2009 1.00 (1.00, 1.00) 42.27
Fischer et al 2003 1.01 (1.00, 1.01) 0.53
Yang(≥20°C) et al 2007 1.05 (1.04, 1.05) 1.84
Yang(<20°C) et al 2007 0.99 (0.96, 1.01) 0.23
Lee(≥20°C) et al 2007 1.08 (1.05, 1.10) 0.07
Lee(<20°C) et al 2007 1.16 (1.12, 1.19) 0.05
Cho et al 2013 1.04 (0.94, 1.15) 0.00
Tian et al 2014 0.99 (0.99, 1.00) 2.31
Sunyer et al 2001 1.00 (1.00, 1.00) 23.18
Overall (I-squared = 97.0%, p = 0.000) 1.00 (1.00, 1.00) 100.00
.9
1
1.1

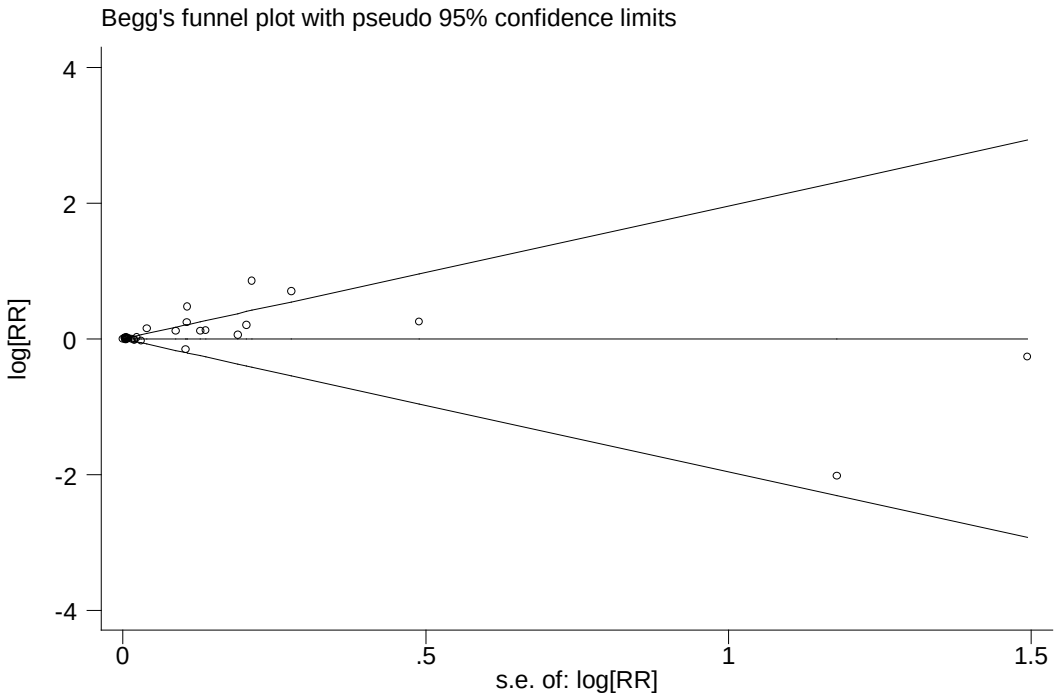
Figure S2



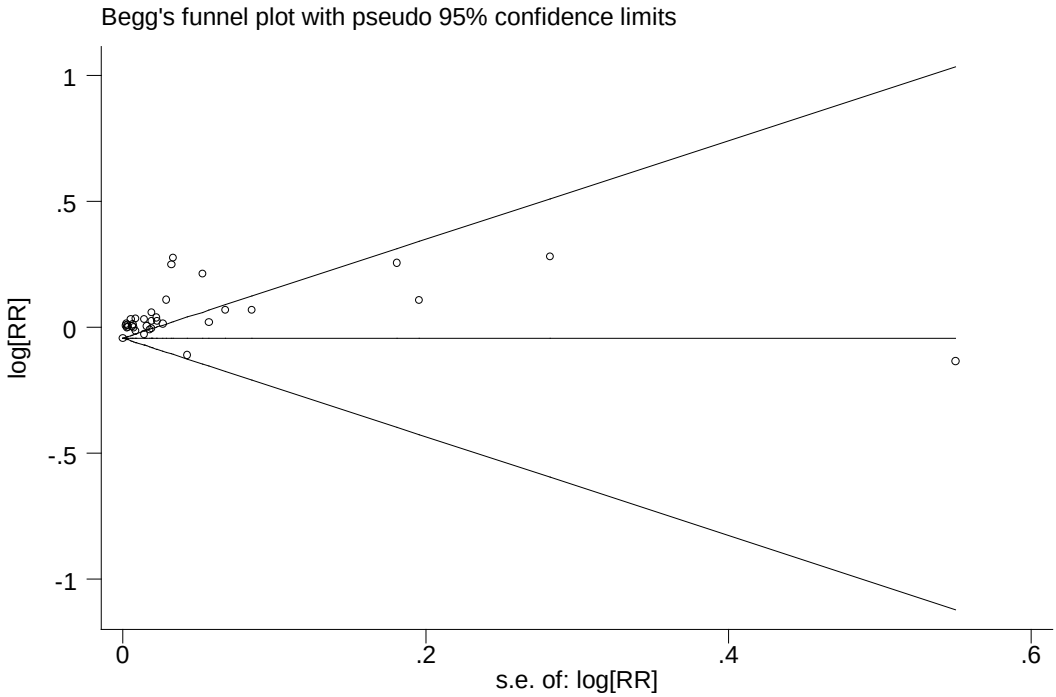
A: Carbon monoxide



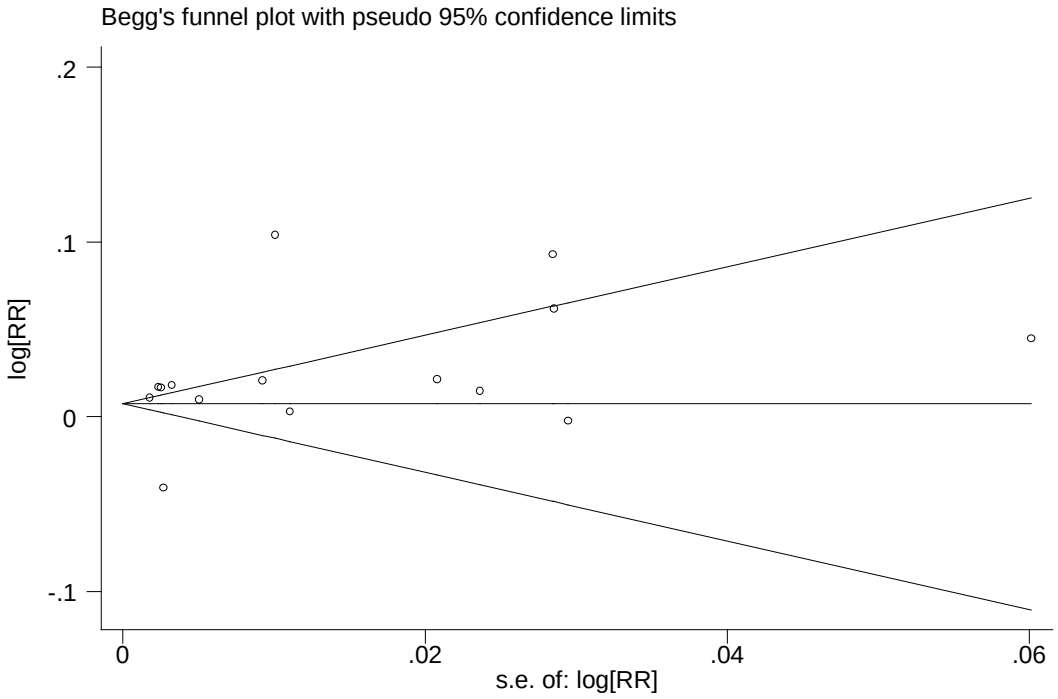
B: Nitrogen dioxide



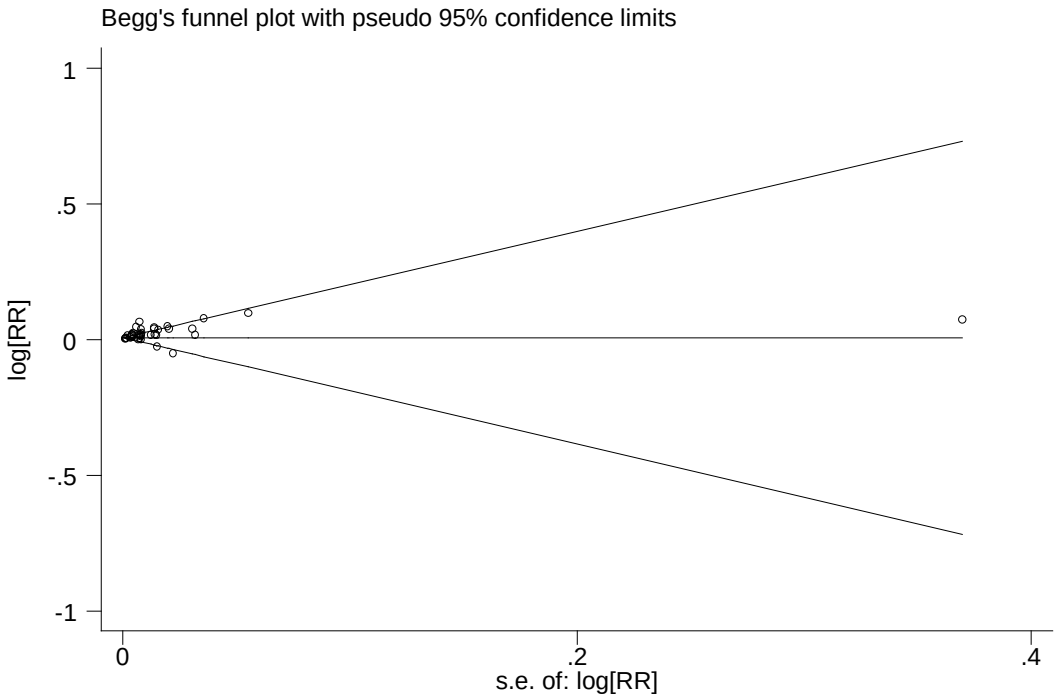
C: Sulphur dioxide



D: Ozone


Begg's funnel plot with pseudo 95% confidence limits
.2
.1
0
-.1
log[RR]
0
.02
.04
.06
s.e. of: log[RR]

E: $PM_{2.5}$


Begg's funnel plot with pseudo 95% confidence limits
1
.5
0
-.5
-1
log[RR]
0
.2
.4
s.e. of: log[RR]

F: PM_{10}

Supplementary Figure Legends

Figure S1 Association between air pollutants and hospitalization/mortality for COPD in overall analyses

Figure S2 Funnel plots for RR of mortality/ hospitalization for COPD exposure to air pollutants

Supplementary Included Reference

1. Kloog I, Nordio F, Zanobetti A, Coull BA, Koutrakis P, Schwartz JD. Short term effects of particle exposure on hospital admissions in the Mid-Atlantic states: a population estimate. *PloS one* 2014;9(2):e88578.
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