공해와 폐질환

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History of air pollution

- **Great Smog, London, 1952**

:19-20세기 석탄 연소가 늘면서 스모그가 자주 발생

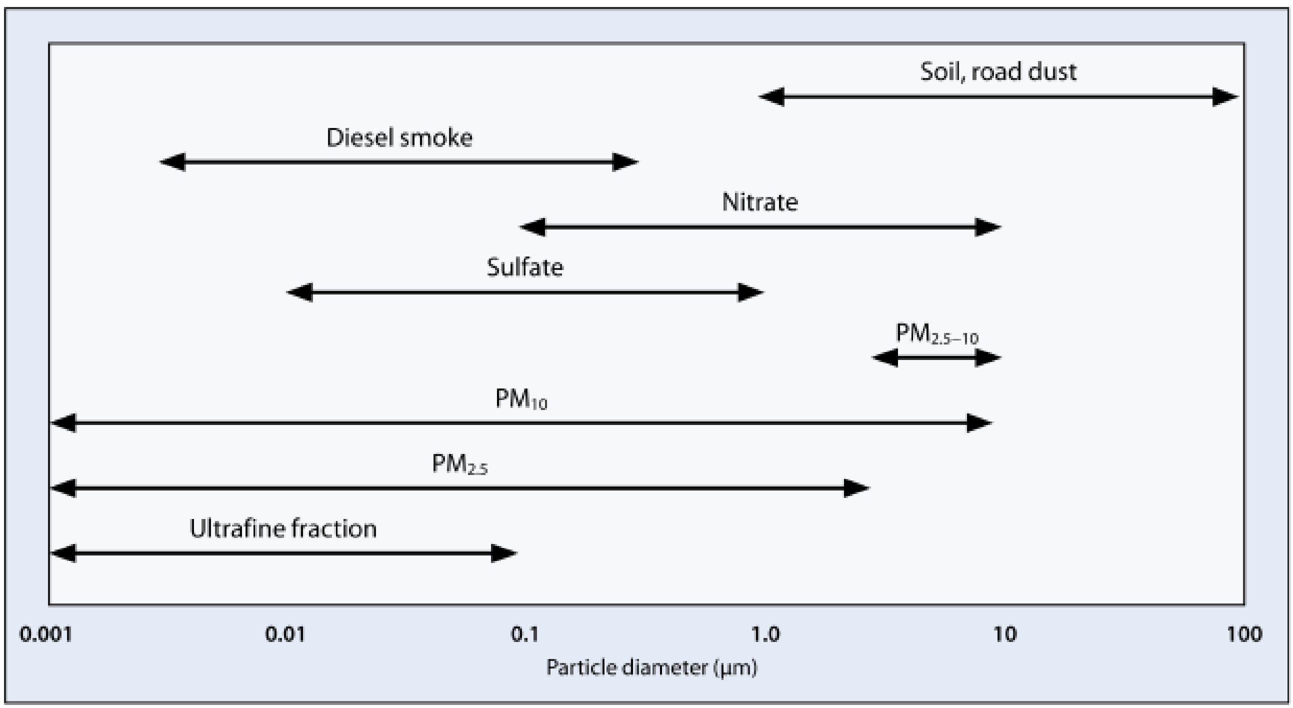
:1952년 12월 5일 간 과도한 난방과 디젤 차량, 화력 발전에서 발생하는 아황산가스(sulfur dioxide, SO_2)로 인한 황산(H_2SO_4) 안개 형성

:수주 동안 12,000명 이상 사망, 주로 노인, 어린이, 만성 질환자

Basic definition of air pollution

- Primary air pollutants/secondary air pollutants
- Gaseous air pollutants/particulate air pollutants

Fig. 1. Size range of airborne particles, showing the health-related ultrafine, $PM_{2.5}$ and PM_{10} fractions and the typical size range of some major components



WHO Air quality guidelines

Pollutants		Guidelines (WHO 2005)	
PM	**PM10**	20 $\mu g/m^3$ annual mean	50 $\mu g/m^3$ 24-hour mean
	PM2.5	10 $\mu g/m^3$ annual mean	25 $\mu g/m^3$ 24-hour mean
Ozone		100 $\mu g/m^3$ 8-hour mean	
NO_2		40 $\mu g/m^3$ annual mean	200 $\mu g/m^3$ 1-hour mean
SO_2		20 $\mu g/m^3$ 24-hour mean	500 $\mu g/m^3$ 10-min. mean

WHO air quality guidelines, 2005

미세먼지, Particulate Matter

- Particulate matter less than 10 μm in diameter; PM10

  Coarse;PM10(미세먼지), Fine;PM2.5(초미세먼지), Ultrafine;PM0.1(극미세먼지)
- 대기 중 떠다니는 대기분진 중 직경이 10 μm 이하로 인체에 흡입되어 폐포에 침착될 수 있는 분진

- 조성: 발생원에 따라 다양, 중금속, 산성 유해물질 포함
- 발생원: 화석 연료의 연소과정에서 배출되는 인위적 발생

  자연 환경 자체에 의한 발생 (예; 황사)

- 국내 미세먼지 구성:

  중국의 미세먼지, 황사 + 국내 대기오염물질

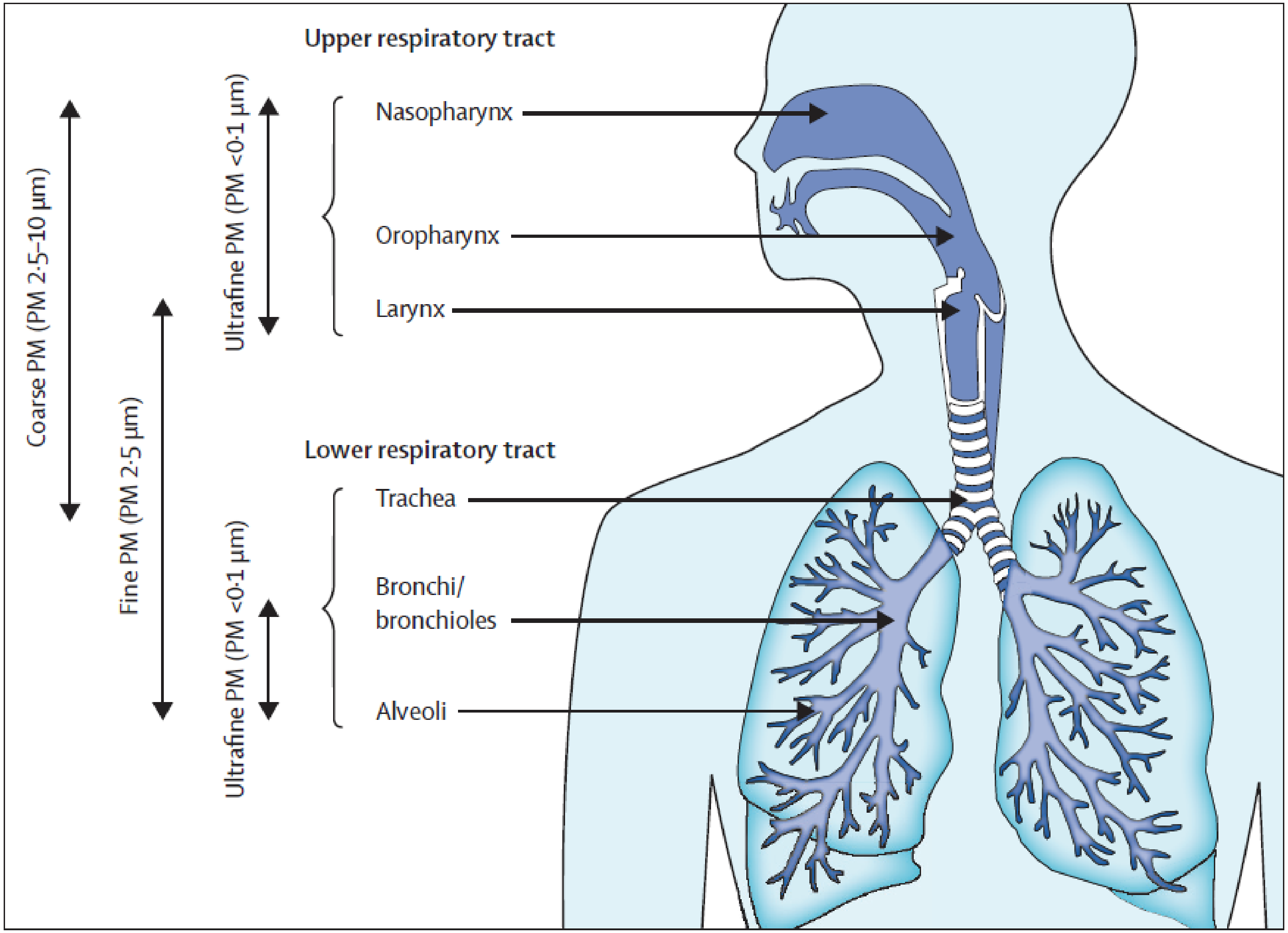


Figure 4: **Compartmental deposition of particulate matter**

Guarnieri et al, Lancet 2014.

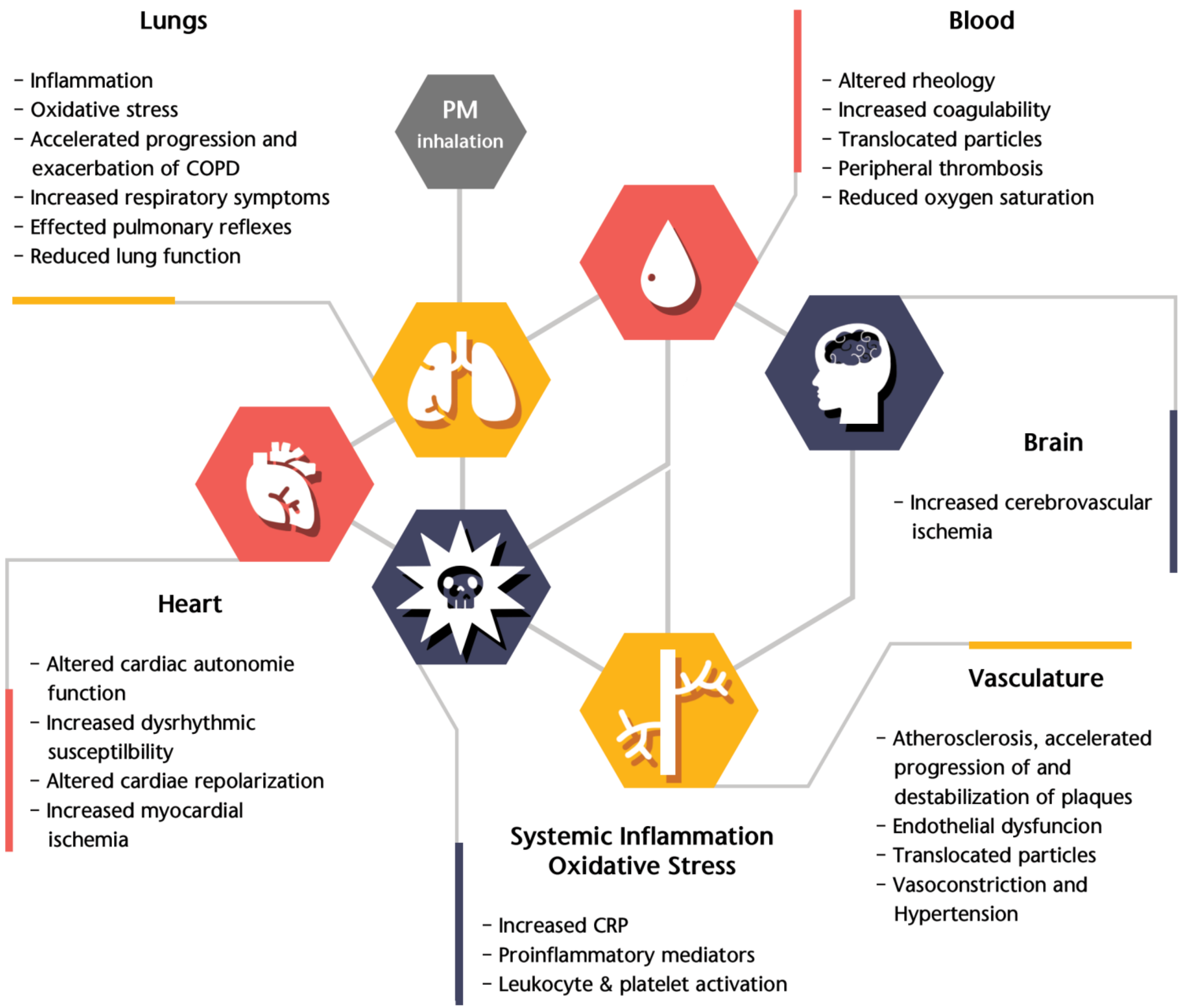
미세먼지의 건강 영향

미세먼지의 건강영향

단기노출의 영향	장기노출의 영향
폐 염증반응	하기도 증상 증가
호흡기 증상	어린이 폐기능 저하
심혈관계의 부정적 영향	만성폐쇄성폐질환 증가
약 사용 증가	성인 폐기능 저하
병원 입원 증가	심폐 사망률 및 폐암으로 인한 기대여명 감소
사망률 증가	

출처: WHO (2004)

미세먼지의 건강영향 기전



Modified from Pope III and Dockery, 2006

미세먼지와 사망률 증가

- 미세먼지 10 $\mu g/m^3$ 증가 시,

  전체 사망률 0.51%

  심혈관 및 호흡기계 질환 사망률 0.68% 증가

Samet et al. N Eng J Med 2000.

Mortality	STUDY	RESULTS	Region
Acute	NMMAPS	0.2% daily deaths per PM10 10 μg/m^3	USA (90)
Acute	APHEAS	0.6% daily mortality per PM10 10 μg/m^3	Europe (29)
Cohort: Survival	HSCS	Mortality per PM2.5	USA (6)
Cohort: Survival	ACSS	Mortality per PM2.5	USA

미세먼지와 폐기능 저하

Source	Study design	Pollution	연구내용	No	Study period	Age ranges
Oftedal et al.	Cross-sectional	**PM2.5/10**	**PEF**	2,307		9-10세
Raizenne et al.	Cross-sectional	**PM**	**FVC, FEV1, FEV0.75, FEF25-75, PEFR<85%**	10,251		8-12세
Peters et al.	Cross-sectional	**PM2.5/10**	**FVC, FEV1, MMEF, PEF**	3,293		9-16세
Gauderman et al.	Prospective cohort	**PM2.5**	**FEV1 100ml/8yrs**	1,759	8년	평균 10세
Avol et al.		**PM10**	**폐기능성장속도 감소**	110		
Rojas-Martinez et al.		**PM10**	**폐기능성장속도 감소**		3년	
Abbey et al. (NHANES)	Cohort	**PM10>100 ug/m3**	**FEV1**			
Downs et al. (SAPALDIA)	Cohort	**PM10 annual mean 10 ug/m3**	**FVC 3.4%, FEV1 1.6% 감소 (성인 폐기능감소속도 증가)**	9,651		18-60세
Schikowski et al. (SALIA)	Cohort	**PM10 10 ug/m3 증가시**	**FEV1 1.3% FVC 1.7% 감소**			

- Children's Health Study
- 10-18세 어린이 (n=1,759), 폐기능 검사 추적 관찰 (8년)

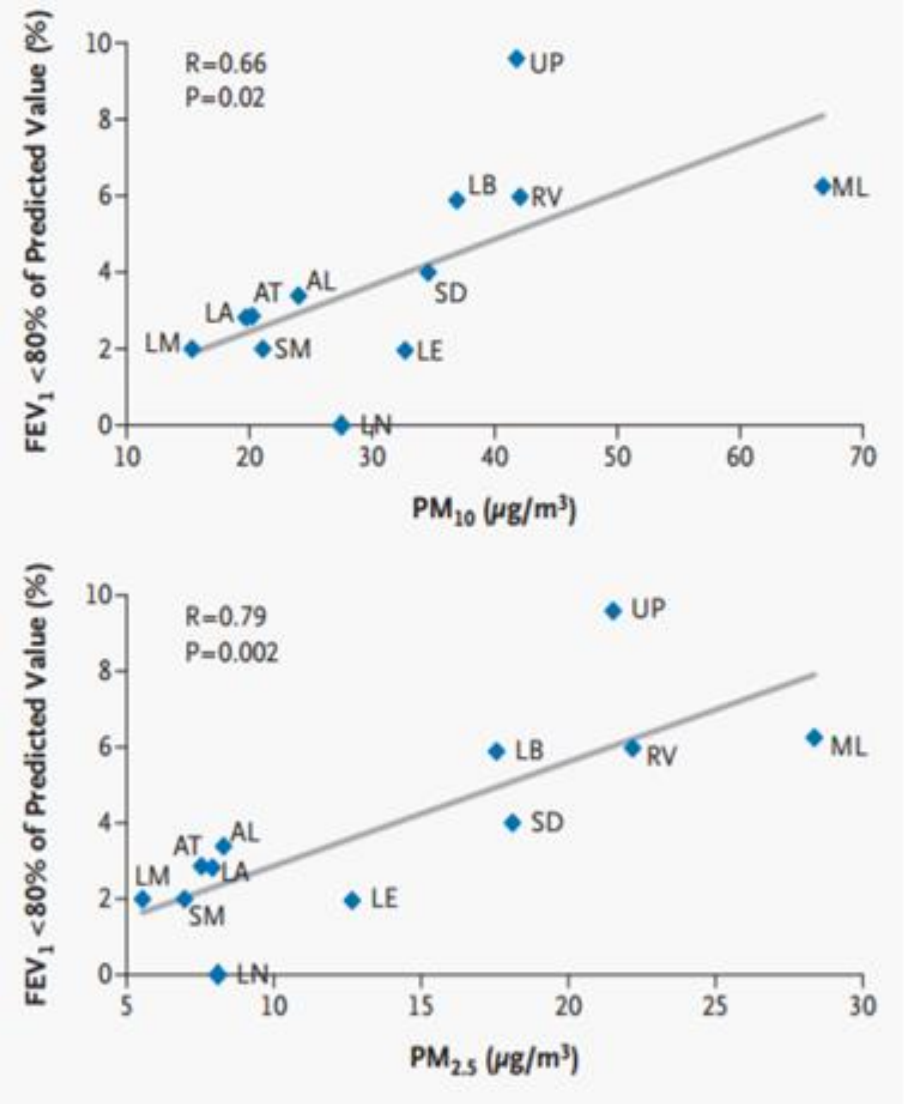
Gauderman et al. N Eng J Med 2004.

1. 대기오염물질의 폐기능 검사 영향 (8년)

Pollutant	FVC		FEV_1		MMEF	
	Difference (95% CI) *ml*	P Value	Difference (95% CI) *ml*	P Value	Difference (95% CI) *ml/sec*	P Value
O_3						
10 a.m.–6 p.m.	−50.6 (−171.0 to 69.7)	0.37	−22.8 (−122.3 to 76.6)	0.62	85.6 (−130.0 to 301.1)	0.40
1-Hour maximal level	−70.3 (−183.3 to 42.6)	0.20	−44.5 (−138.9 to 50.0)	0.32	45.7 (−172.3 to 263.6)	0.65
NO_2	−95.0 (−189.4 to −0.6)	0.05	−101.4 (−164.5 to −38.4)	0.005	−211.0 (−377.6 to −44.4)	0.02
Acid vapor	−105.2 (−194.5 to −15.9)	0.03	−105.8 (−168.8 to −42.7)	0.004	−165.0 (−344.8 to 14.7)	0.07
PM_{10}	−60.2 (−190.6 to 70.3)	0.33	−82.1 (−176.9 to 12.8)	0.08	−154.2 (−378.3 to 69.8)	0.16
$PM_{2.5}$	−60.1 (−166.1 to 45.9)	0.24	−79.7 (−153.0 to −6.4)	0.04	−168.9 (−345.5 to 7.8)	0.06
Elemental carbon	−77.7 (−166.7 to 11.3)	0.08	−87.9 (−146.4 to −29.4)	0.007	−165.5 (−323.4 to −7.6)	0.04
Organic carbon	−58.6 (−196.1 to 78.8)	0.37	−86.2 (−185.6 to 13.3)	0.08	−151.2 (−389.4 to 87.1)	0.19

* Values are the differences in the estimated rate of eight-year growth at the lowest and highest observed levels of the indicated pollutant. Dif-

2. 미세먼지 농도에 따른 FEV1<80% 소아의 비율



- SAPALDIA study
- 18-60세 성인 (n=9,651), 폐기능 검사 추적 관찰 (11년)

Downs et al. N Eng J Med 2007.

PM10 연평균 농도에 따른 FEV1 mean annual decline

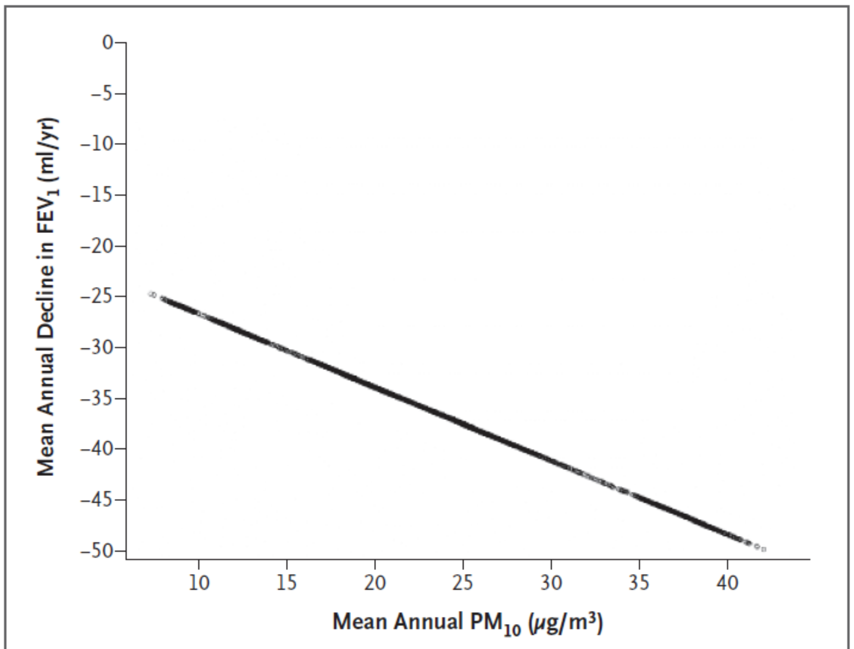


Figure 3. Estimated Effect of Interval Exposure between 1991 and 2002 (Expressed as Mean Annual PM_{10}) on Mean Annual Decline in FEV_1.
The mixed model was refitted with a penalized spline and the use of generalized cross-validation. Interval exposure has been converted to mean annual exposure during the interval for ease of interpretation. PM_{10} denotes particulate matter with an aerodynamic diameter of less than 10 μm, and FEV_1 forced expiratory volume in 1 second.

Effect of change in PM10 on annual FEV1 decline

Table 2. Estimated Effect of Change in PM_{10} and of Interval Exposure to PM_{10} on Annual Change in Lung Function.*

Variable	No. of Participants	Decrease in PM_{10} of 10 $\mu g/m^3$ between 1991 and 2002		Decrease in Interval Exposure of 109 $\mu g/m^3$-yr	
		Effect (95% CI)	P Value	Effect (95% CI)	P Value
All participants	4742				
FVC (ml)		−0.2 (−4.3 to 3.9)	0.91	5.3 (−1.1 to 11.7)	0.10
FEV_1 (ml)		3.1 (0.03 to 6.2)	0.045	6.9 (2.1 to 11.7)	0.005
FEV_1 as a percentage of FVC		0.06 (0.01 to 0.12)	0.02	0.05 (−0.04 to 0.13)	0.27
FEF_{25-75} (ml/sec)		11.3 (4.3 to 18.2)	0.001	14.0 (3.1 to 24.8)	0.01
All participants who never smoked	2213				
FVC (ml)		2.2 (−3.4 to 7.9)	0.43	9.9 (1.3 to 18.4)	0.02
FEV_1 (ml)		4.2 (−0.3 to 8.5)	0.06	9.3 (2.6 to 16.0)	0.006
FEV_1 as a percentage of FVC		0.05 (−0.03 to 0.13)	0.18	0.03 (−0.08 to 0.15)	0.59
FEF_{25-75} (ml/sec)		11.3 (1.4 to 21.2)	0.03	15.4 (0.2 to 30.6)	0.047

- Decreasing exposure to airborne particulates appears to attenuate the decline in lung function related to exposure to PM10.

- Adult lung function and lung-term air pollution exposure
- ESCAPE: a multicenter cohort study and meta-analysis

ECRHS, EGEA, NSHD, SALIA and SAPALDIA.

Adam et al. Eur Respir J 2015.

TABLE 3 Results of meta-analyses for the association between level and change of lung function and exposure to air pollution and traffic intensity indicators

Exposure (increment)	Level of lung function (mL)#					
	FEV_1			FVC		
	Beta¶	95% CI	I^2 § p-value (het)	Beta¶	95% CI	I^2 § p-value (het)
NO_2 (10 $\mu g \cdot m^{-3}$)	−13.98	−25.82 to −2.14	0.0% p=0.625	−14.93	−28.73 to −1.13	0.0% p=0.977
NO_x (20 $\mu g \cdot m^{-3}$)	−12.91	−23.79 to −2.04	0.0% p=0.861	−13.25	−25.85 to −0.65	0.0% p=0.962
PM_{10} (10 $\mu g \cdot m^{-3}$)	−44.56	−85.36 to −3.76	0.0% p=0.628	−58.96	−112.27 to −5.65	0.0% p=0.785
$PM_{2.5}$ (5 $\mu g \cdot m^{-3}$)	−21.14	−56.37 to 14.08	0.0% p=0.535	−36.39	−83.29 to 10.50	0.0% p=0.877
$PM_{2.5}$ absorbance (1×10^{-5} m^{-1})	−24.40	−55.58 to 6.79	0.0% p=0.709	−12.94	−50.23 to 24.30	0.0% p=0.619
Coarse PM (5 $\mu g \cdot m^{-3}$)	−22.36	−94.00 to 49.27	12.6% p=0.333	2.88	−87.85 to 93.60	0.0% p=0.760
Traffic intensity on nearest road (high/low)ƒ,##	−27.61	−59.62 to 4.39	29.0% p=0.228	−10.37	−48.23 to 27.49	27.3% p=0.239
Traffic load on nearest major road in a 100-m buffer (high/low)##,¶¶	−32.34	−59.30 to −5.38	0.0% p=0.784	−18.64	−50.22 to 12.94	0.0% p=0.967

미세먼지와 폐암

- Air pollution and lung cancer incidence in 17 European cohorts: prospective analyses from the European Study of Cohorts for Air pollution effects (ESCAPE)
- Europe의 17개 cohorts (n=312,944) 를 이용하여 유럽에서 air pollution (PM, NOx)과 Lung cancer 발생 위험도를 분석함 (12.8 yrs)

Raaschou-Noelsem et al. Lancet Oncol 2013.

Meta-analysis of association between risk for lung cancer and PM

	Increase	Number of cohorts	HR (95% CI)			Measures of heterogeneity between cohorts (model 3)	
			Model 1*	Model 2†	Model 3‡	I^2	p value
PM_{10}	10 μg/m³	14	1·32 (1·12–1·55)	1·21 (1·03–1·43)	1·22 (1·03–1·45)	0·0%	0·83
$PM_{2.5}$	5 μg/m³	14	1·34 (1·09–1·65)	1·17 (0·95–1·45)	1·18 (0·96–1·46)	0·0%	0·92
PM_{coarse}	5 μg/m³	14	1·19 (0·99–1·42)	1·08 (0·89–1·31)	1·09 (0·88–1·33)	33·8%	0·11
$PM_{2.5absorbance}$	10^{-5}/m	14	1·25 (1·05–1·50)	1·09 (0·87–1·37)	1·12 (0·88–1·42)	19·0%	0·25
NO_2	10 μg/m³	17	1·07 (1·00–1·14)	0·99 (0·93–1·06)	0·99 (0·93–1·06)	0·0%	0·70
NOx	20 μg/m³	17	1·08 (1·02–1·14)	1·01 (0·95–1·06)	1·01 (0·95–1·07)	0·0%	0·62
Traffic density on nearest road	5000 vehicles per day	15	1·02 (0·98–1·06)	1·00 (0·97–1·04)	1·00 (0·97–1·04)	0·0%	0·90
Traffic load on major roads within 100 m	4000 vehicle-km per day	16	1·10 (1·00–1·21)	1·07 (0·97–1·18)	1·09 (0·99–1·21)	0·0%	0·92

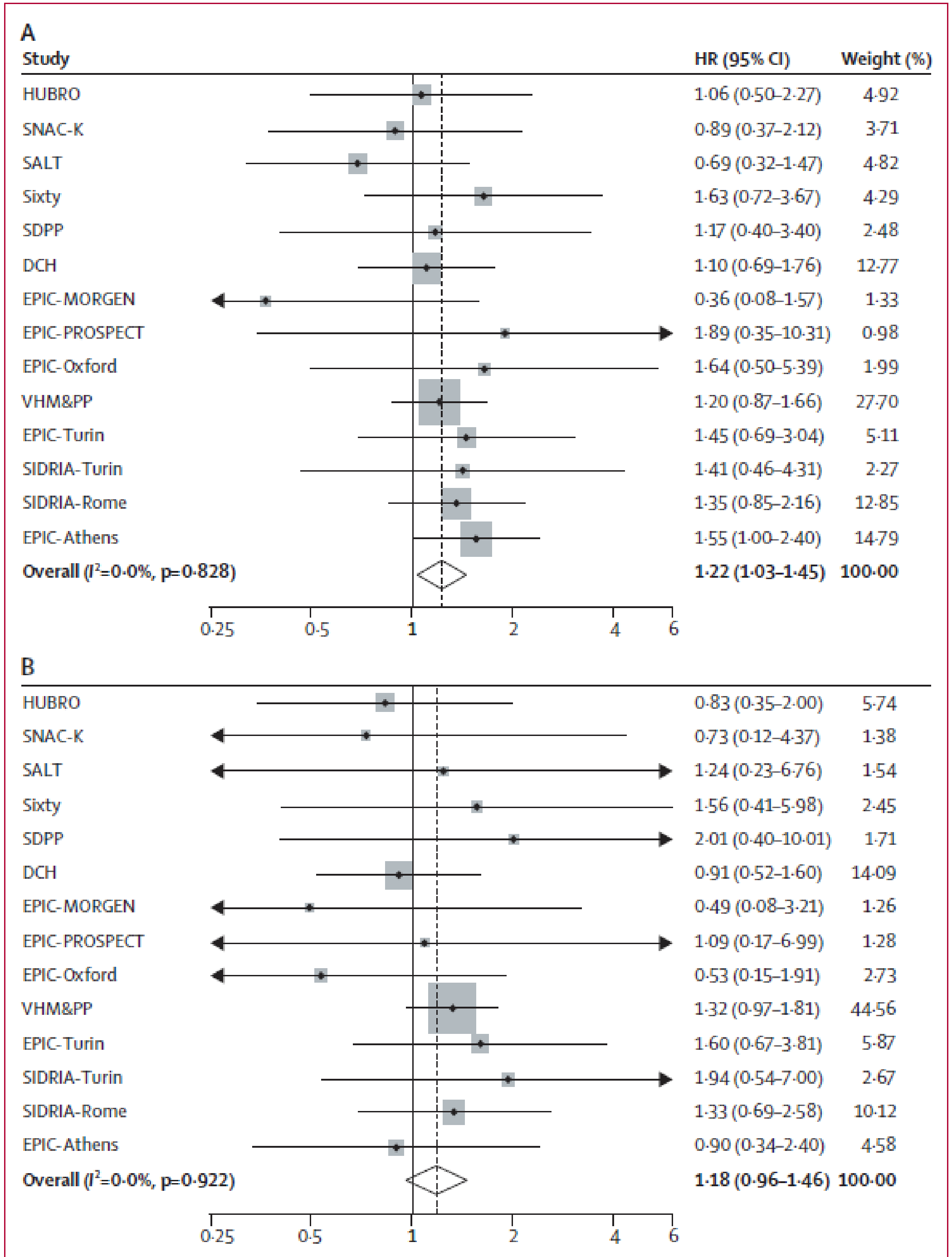


Figure 3: Risk for lung cancer according to concentration of particulate matter in each cohort study

Association between PM and risk for lung cancer according to histological cancer subtype

	Number of cohorts	HR (95% CI) for histological cancer subtype analysis		HR (95% CI) for standard analysis*	
		PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
All participants					
All lung cancers	14†	1·22 (1·03–1·45)	1·18 (0·96–1·46)	1·22 (1·03–1·45)	1·18 (0·96–1·46)
Adenocarcinomas	11‡	1·51 (1·10–2·08)	1·55 (1·05–2·29)	1·22 (1·01–1·47)	1·16 (0·92–1·45)
Squamous-cell carcinomas	7§	0·84 (0·50–1·40)	1·46 (0·43–4·90)	1·19 (0·94–1·51)	1·18 (0·91–1·52)
Participants who did not change residence					
All lung cancers	10¶	1·48 (1·16–1·88)	1·33 (0·98–1·80)	1·22 (1·02–1·46)	1·20 (0·96–1·51)
Adenocarcinomas	8‖	2·27 (1·32–3·91)	1·65 (0·93–2·95)	1·19 (0·98–1·45)	1·17 (0·92–1·49)
Squamous-cell carcinomas	3**	0·64 (0·28–1·48)	0·65 (0·16–2·57)	1·21 (0·94–1·55)	1·22 (0·93–1·60)

Meta-analysis results based on confounder model 3. See appendix (p 25) for numbers of participants and lung cancer cases contributing to each meta-analysis result. HRs are per 10 μg/m³ of PM_{10} and per 5 μg/m³ of $PM_{2.5}$. HR=hazard ratio. PM_{10}=particulate matter with diameter <10 μm. $PM_{2.5}$=particulate matter with diameter <2·5 μm. *Standard analysis, disregarding histological cancer subtype (ie, with all lung cancers as the endpoint and including all participants in the same cohorts as used in the histological cancer subtype analysis). †HUBRO, SNAC-K, SALT, Sixty, SDPP, DCH, EPIC-MORGEN, EPIC-PROSPECT, EPIC-Oxford, VHM&PP, EPIC-Turin, SIDRIA-Turin, SIDRIA-Rome, EPIC-Athens. ‡HUBRO, SALT, Sixty, SDPP, DCH, EPIC-MORGEN, EPIC-PROSPECT, EPIC-Oxford, VHM&PP, EPIC-Turin, EPIC-Athens. §Sixty, SDPP, DCH, EPIC-MORGEN, EPIC-PROSPECT, EPIC-Oxford, VHM&PP. ¶HUBRO, SNAC-K, SALT, Sixty, SDPP, DCH, VHM&PP, SIDRIA-Turin, SIDRIA-Rome, EPIC-Athens. ‖HUBRO, SNAC-K, SALT, Sixty, SDPP, DCH, VHM&PP, EPIC-Athens. **Sixty, DCH, VHM&PP.

***Table 3*: Associations between PM_{10} and $PM_{2.5}$ and risk for lung cancer for all participants and those who did not change residence during follow-up, according to histological cancer subtype**

Mechanisms and biomarkers: air pollution and lung cancer

Table 11.1 Summary and examples of positive findings from human biomarker studies investigating combustion-related outdoor or indoor air pollution

Type of damage	Excreta/cell type studied	Main type of particulate exposure	Reference
Bacterial mutagenicity	Urine (adults)	Outdoor air pollution (urban/ traffic exhausts)	Hansen *et al.* (2004)
DNA damage			
Bulky/aromatic or PAH–DNA adducts	White blood cells/lymphocytes from peripheral blood, umbilical cord leukocytes (adults, newborn infants of mothers with exposure)	Outdoor air pollution (urban/ traffic exhausts, industrial site, coal heating)	Farmer *et al.* (1996) Peluso *et al.* (1998) Whyatt *et al.* (1998) Autrup *et al.* (1999) Palli *et al.* (2001) Ruchirawa *et al.* (2002) Perera *et al.* (2005) Demetriou *et al.* (2012)
		Indoor air pollution (emissions from domestic smoky coal combustion)	Mumford *et al.* (1993)
	Placenta	Indoor air pollution (emissions from domestic smoky coal combustion)	Mumford *et al.* (1993)
Oxidative (8-oxo-2'-deoxyguanosine)	White blood cells/lymphocytes from peripheral blood, nasal epithelium (adults, children)	Outdoor air pollution (urban/ traffic exhausts)	Calderøn-Garciduenas *et al.* (1996, 1997, 1999) Loft *et al.* (1999) Sorensen *et al.* (2003a, 2003b) Demetriou *et al.* (2012)
DNA damage/strand breaks/tail length in comet assay	White blood cells from peripheral blood, nasal epithelium (adults, children)	Outdoor air pollution (urban/ traffic exhausts, industrial site)	Valverdere *et al.* (1997) Calderon-Garciduenas *et al.* (1996, 1997, 1999)
DNA fragmentation (%)	Sperm cells	Outdoor air pollution (coal heating, industrial site)	Rubes *et al.* (2005)

IARC and WHO, Air pollution and cancer 2013.

Table 11.1 (continued)

Type of damage	Excreta/cell type studied	Main type of particulate exposure	Reference
Cytogenetic effects			
Chromosome aberrations, micronuclei, or sister chromatid exchanges	Lymphocytes from peripheral blood, buccal cells (adults, children)	Outdoor air pollution (urban/ traffic exhausts, industrial site)	Chandrasekaran *et al.* (1996) Zhao *et al.* (1998) Michalska *et al.* (1999) Burgaz *et al.* (2002) Huen *et al.* (2006) Ishikawa *et al.* (2006) Sreedevi *et al.* (2006, 2009) Rossnerova *et al.* (2009)
Gene mutations			
HPRT gene	Lymphocytes from umbilical cord blood (newborn infants of mothers with exposure)	Outdoor air pollution (urban/ traffic exhausts, heating), transplacental exposure	Perera *et al.* (2002)
TP53 gene	Lung tumour tissue (nonsmokers), lung epithelial cells in sputum from nonsmokers with no evidence of cancer	Indoor air pollution (emissions from domestic smoky coal combustion)	DeMarini *et al.* (2001) Keohavong *et al.* (2005)
K-ras (or *NRAS* or *HRAS*) gene	Lung tumour tissue (nonsmokers), lung epithelial cells in sputum from nonsmokers with no evidence of cancer	Indoor air pollution (emissions from domestic smoky coal combustion)	DeMarini *et al.* (2001) Keohavong *et al.* (2003) Keohavong *et al.* (2005)
Differential DNA methylation			
Increased methylation in gene promoter region (*ACSL3* gene, *INF-γ* gene)	Leukocytes from umbilical cord blood (newborn infants of mother with exposure)	Outdoor air pollution (urban/ traffic exhausts)	Perera *et al.* (2009) Tang *et al.* (2012)
Decreased methylation of *NOS1*, *NOS2A*, or *NOS3* gene (various CpG loci or gene promoter)	Buccal cells (children)	Outdoor air pollution (urban/ traffic exhausts, residential communities)	Breton *et al.* (2012) Salam *et al.* (2012)
Hypomethylation of LINE-1 and/ or ALU repeats	White blood cells from peripheral blood (adults)	Outdoor air pollution (urban/ traffic exhausts)	Baccarelli *et al.* (2009) Madrigano *et al.* (2011)
Decreased global DNA methylation	Leukocytes from umbilical cord blood (newborn infants of mothers with exposure)	Outdoor air pollution (urban/ traffic exhausts)	Herbstman *et al.* (2012)

IARC and WHO, Air pollution and cancer 2013.

미세먼지와 COPD

- Incidence, prevalence of COPD
- Exacerbation of COPD: ER visit or admission
- Mortality of COPD

TABLE 3 Examples of respiratory clinical effects associated with air pollution
Increased respiratory mortality
Increased incidence of malignancies of the respiratory tract
Increased incidence, prevalence or frequency of exacerbations in chronic pulmonary disease: asthma, COPD and cystic fibrosis
Increased incidence or severity of upper and lower respiratory tract infections
Increased respiratory symptoms that affect quality of life: cough, phlegm, wheezing, dyspnoea and nasal drainage
Increased incidence of preterm birth, low birthweight or growth restriction leading to adverse respiratory outcomes
Reduced growth of lung function in children
Transient (hours) reductions in lung function associated with symptoms in healthy individuals
Transient (hours) reductions in lung function without symptoms in especially susceptible individuals (*e.g.* children with severe asthma)
Persistent or chronic (weeks, months or years) reductions in lung function

COPD: chronic obstructive pulmonary disease.

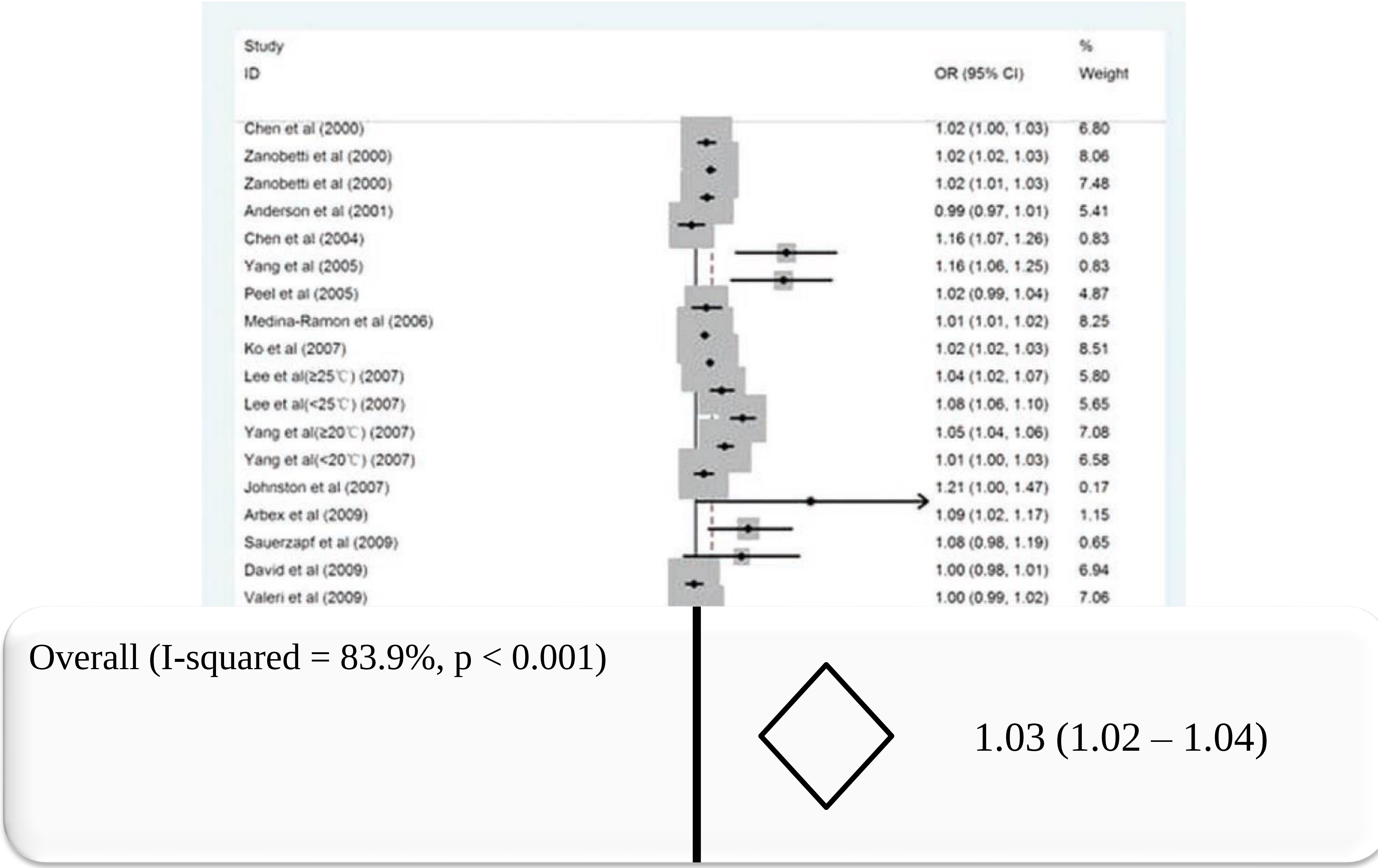
Thurston et al. Eur Respir J 2017

- Association between COPD admission and PM10
- Meta-analysis from

Source	Study design	OR	95% CI	No	Study period	Age ranges
Chen et al.	Time-series	**1.018**	**1.004-1.033**	3,115	1990-1994	All ages
Zanobetti et al.	Time-series	**1.025**	**1.018-1.033**	NA	1986-1994	65세이상
Zanobetti et al.	Time-series	**1.019**	**1.008-1.030**	NA	1986-1994	All ages
Anderson et al.	Time-series	**0.993**	**0.972-1.014**	NA	1994-1996	All ages
Chen et al.	Time-series	**1.162**	**1.068-1.263**	4,409	1995-1999	65세이상
Yang et al.	Time-series	**1.157**	**1.060-1.253**	6,027	1994-1998	65세이상
Peel et al.	Time-series	**1.018**	**0.994-1.043**	NA	1993-2000	All ages
Medina-Ramon	Time-series	**1.015**	**1.093-1.021**	578,006	1986-1999	65세이상
Ko et al.	Time-series	**1.024**	**1.021-1.028**	199,225	2000-2005	All ages
Lee et al.	Case-crossover	**1.044**	**1.025-1.065**	25,108	1996-2003	All ages
		1.081	**1.060-1.103**			
Yang et al.	Case-crossover	**1.050**	**1.037-1.064**	46,491	1996-2003	All ages
		1.013	**0.998-1.029**			
Johnston et al.	Time-series	**1.21**	**1.00-1.47**	NA	2000-2005	All ages
Arbex et al.	Time-series	**1.091**	**1.021-1.174**	1,796	2001-2003	65세이상
Sauerzapf et al.	Case-crossover	**1.079**	**0.980-1.188**	1,050	2006-2007	All ages
David et al.	Time-series	**0.997**	**0.984-1.011**	NA	1990s-2000s	All ages
Belleudi et al.	Case-crossover	**1.003**	**0.990-1.016**	15,087	2001-2005	35세이상
Morgan et al.	Time-series	**1.038**	**1.014-1.063**	36,772	1994-2002	65세이상
Tam et al.	Case-crossover	**1.05**	**1.01-1.09**	111,419	1998-2002	All ages

질병관리본부, 2014

Risk for COPD admission associated with PM10

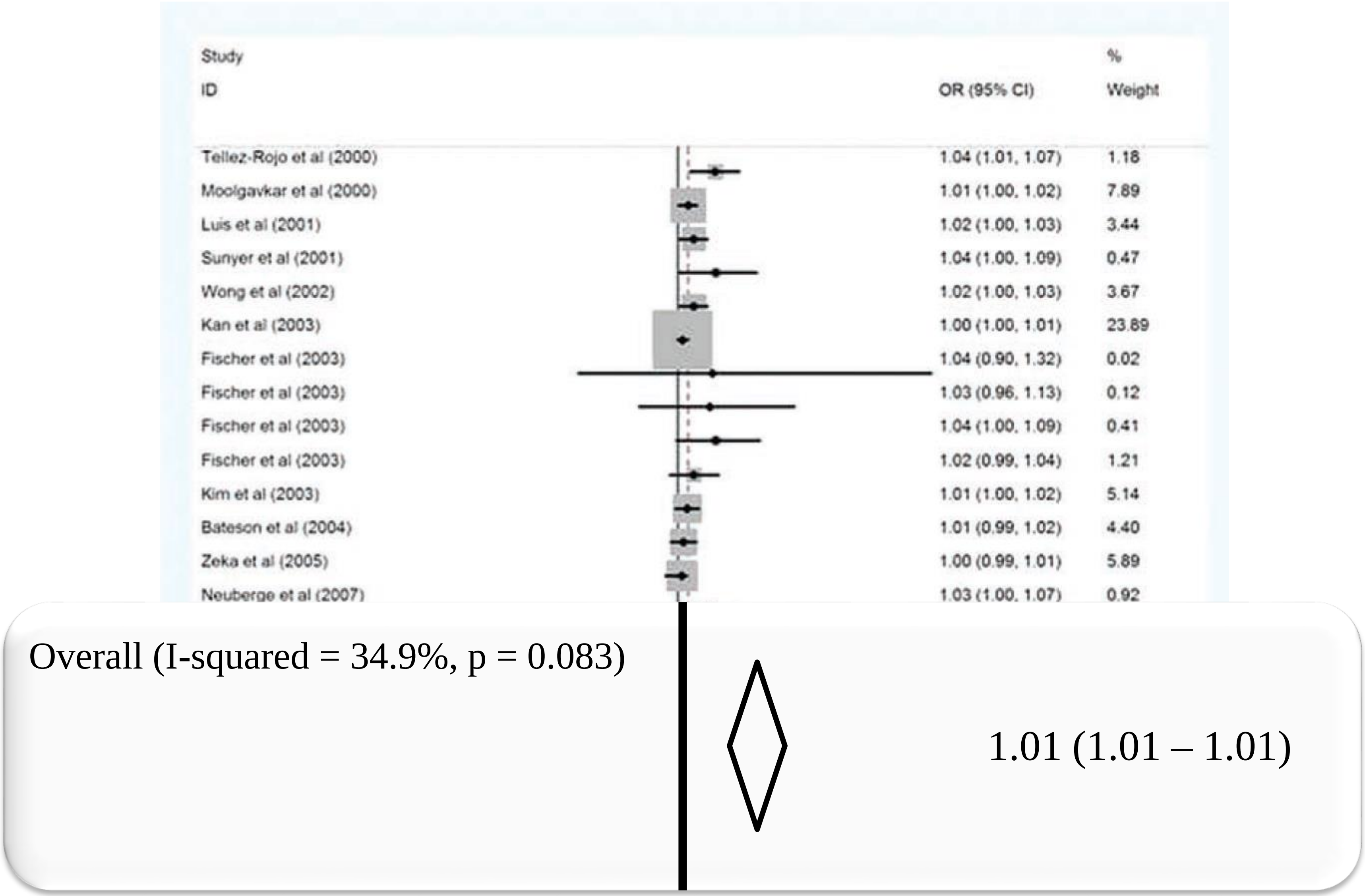


- Association between COPD mortality and PM10
- Meta-analysis from

Source	Study design	OR	95% CI	No	Study period	Age ranges
Tellez-Rojo et al.	Time-series	**1.041**	**1.013-1.069**	2,294	1994	65세이상
Moolgavkar	Time-series	**1.011**	**1.000-1.021**	NA	1987-1995	All ages
Braga et al.	Time-series	**1.017**	**1.001-1.033**	NA	1986-1993	All ages
Sunyer et al.	Case-crossover	**1.042**	**1.000-1.089**	2,305	1990-1995	All ages
Wong et al.	Time-series	**1.017**	**1.002-1.033**	NA	1995-1998	All ages
Kan et al.	Time-series	**1.005**	**0.999-1.011**	NA	2000-2001	All ages
Fischer et al.	Time-series	**1.038**	**0.987-1.317**	NA	1986-1994	45세미만
		1.035	**0.958-1.135**			45-64
		1.042	**0.998-1.093**			65-74
		1.017	**0.991-1.045**			75세이상
Kim et al.	Time-series	**1.010**	**0.997-1.023**	NA	1995-1999	All ages
Bateson et al.	Case-crossover	**1.006**	**0.992-1.020**	16,403	1998-1991	All ages
Zeka et al.	Time-series	**1.004**	**0.986-1.010**	NA	1989-2000	All ages
Neuberger et al.	Time-series	**1.035**	**1.004-1.067**	2,872	2000-2004	All ages
Forastiere et al.	Case-crossover	**1.008**	**1.002-1.015**	34,627	1997-2004	65세이상
Fischer et al.	Time-series	**1.018**	**1.011-1.024**	NA	1992-2006	All ages

질병관리본부, 2014

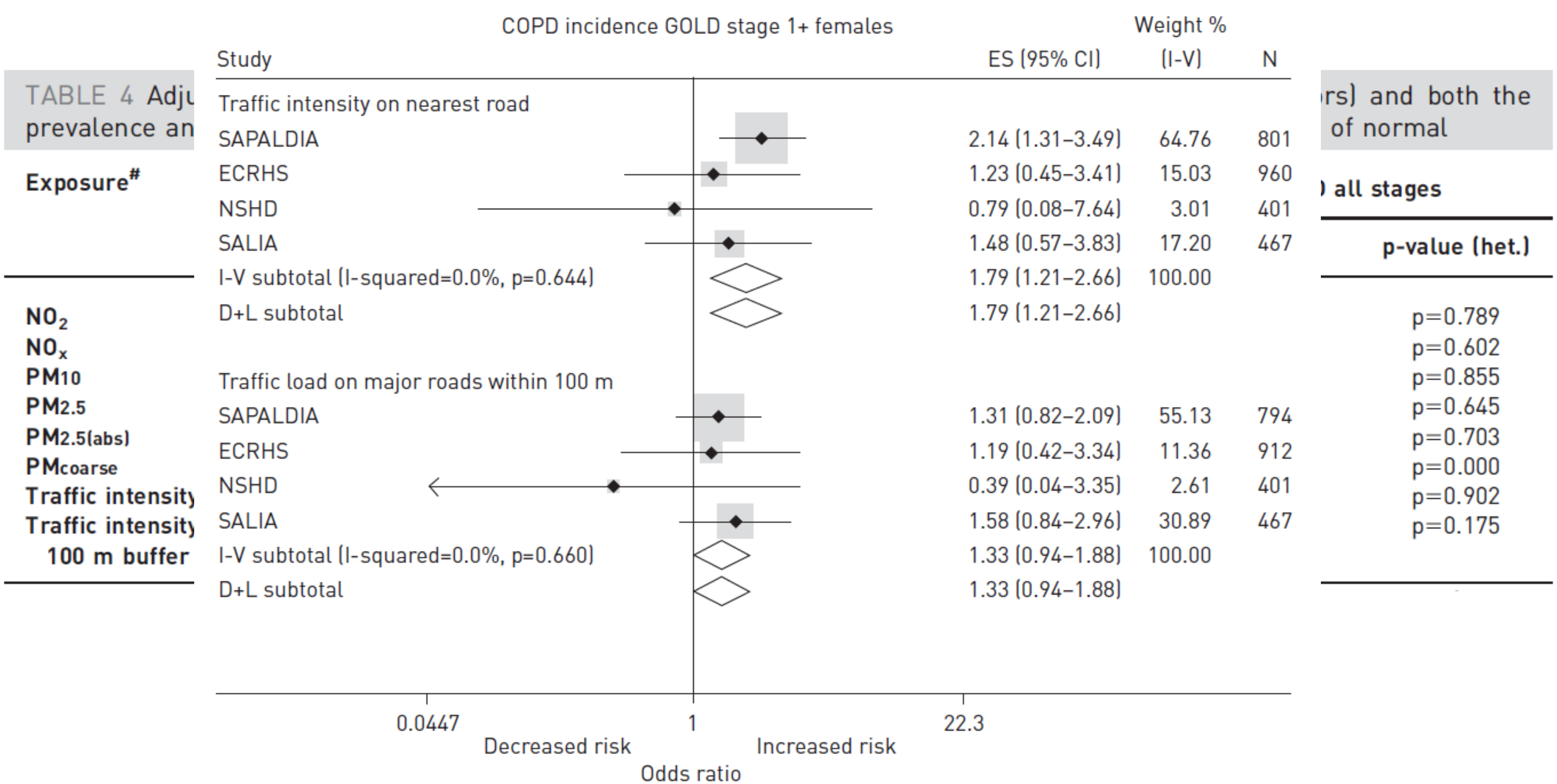
Risk for COPD mortality associated with PM10



- Association of ambient air pollution with the prevalence and incidence of COPD

- 4 Cohorts (n=6,550) using ESCAPE exposure estimates
- COPD and NOx, PM10

Schikowski et al. Eur Respir J 2014.



미세먼지와 기관지천식

Author	Study design	Results	Reference
Merrifield et al	Epidemiologic study Short-term exposure	Large dust storm in Sidney, 2009 Increased ER visit of asthma patients (RR 1.23)	Environ Health 2013
Alskandar et al	Crossover study	PM and hospital admission and children asthma	Thorax 2012
Balmes et al	Cross sectional study	PM exposure and resporatory outcome in adult asthma	Environ Res 2014
Batterman et al	RCT	Children with asthma and in door PM	Indoor Air 2012
Guarnieri et al	Review 2009-2014 studies	Outdoor air pollution and asthma	Lancet 2014
Gruzieva et al	Meta-analysis	Air pollution exposure and allergic senitization in children	JACI 2014

- Outdoor air pollution and asthma
- Review of clinical epidemiologic/experimental studies recent 5 yrs: effect of PM, gaseous pollutants, mixed traffic-related air pollution

Guarnieri et al, Lancet 2014.

- **Short-term exposure** to PM2.5 and PM10 in patients with asthma

Associated with asthma symptoms (children with allergic sensitisation)

Healthcare use

- **Long-term exposure to PM**

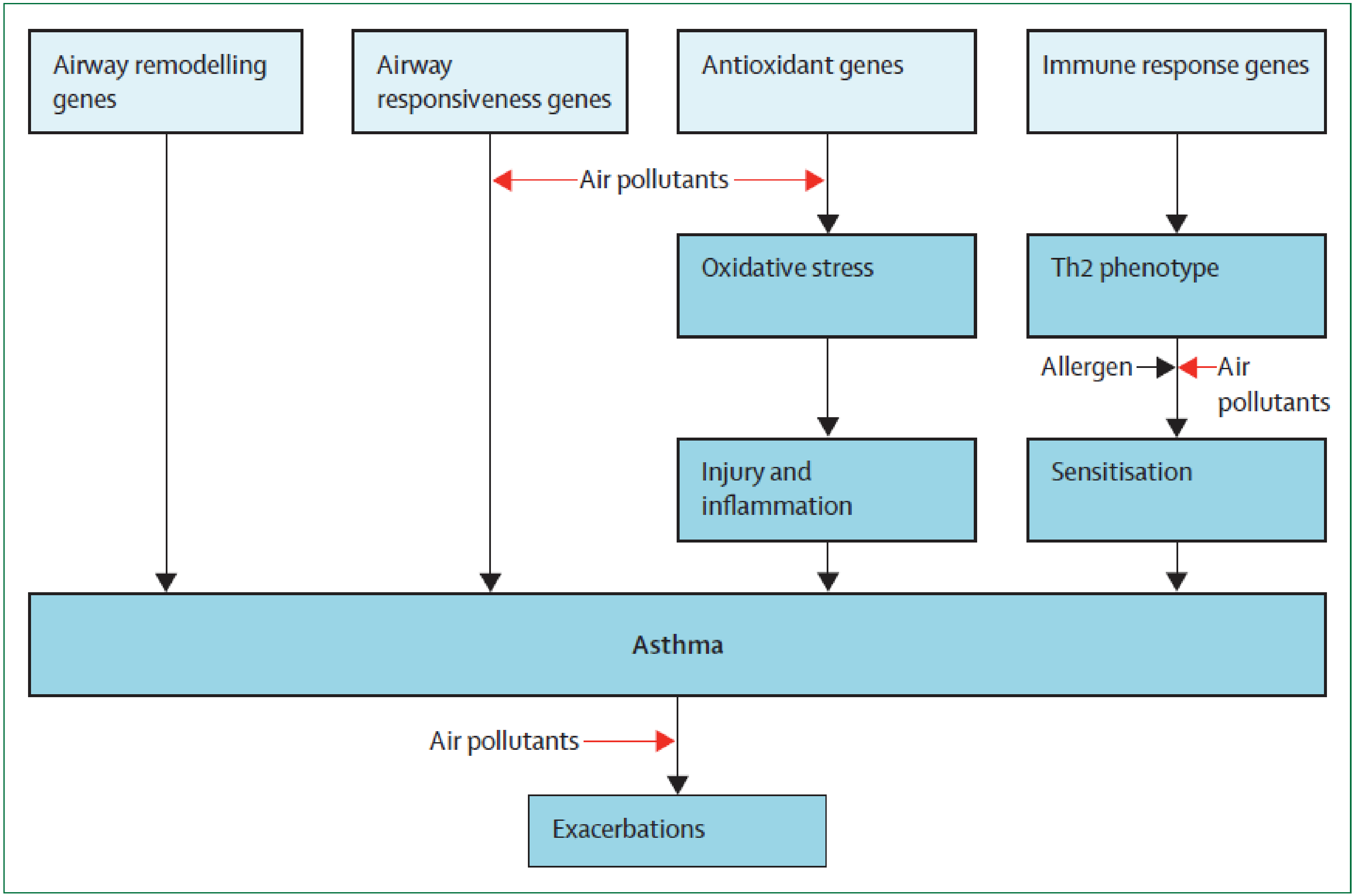
Associated with Poorly controlled asthma

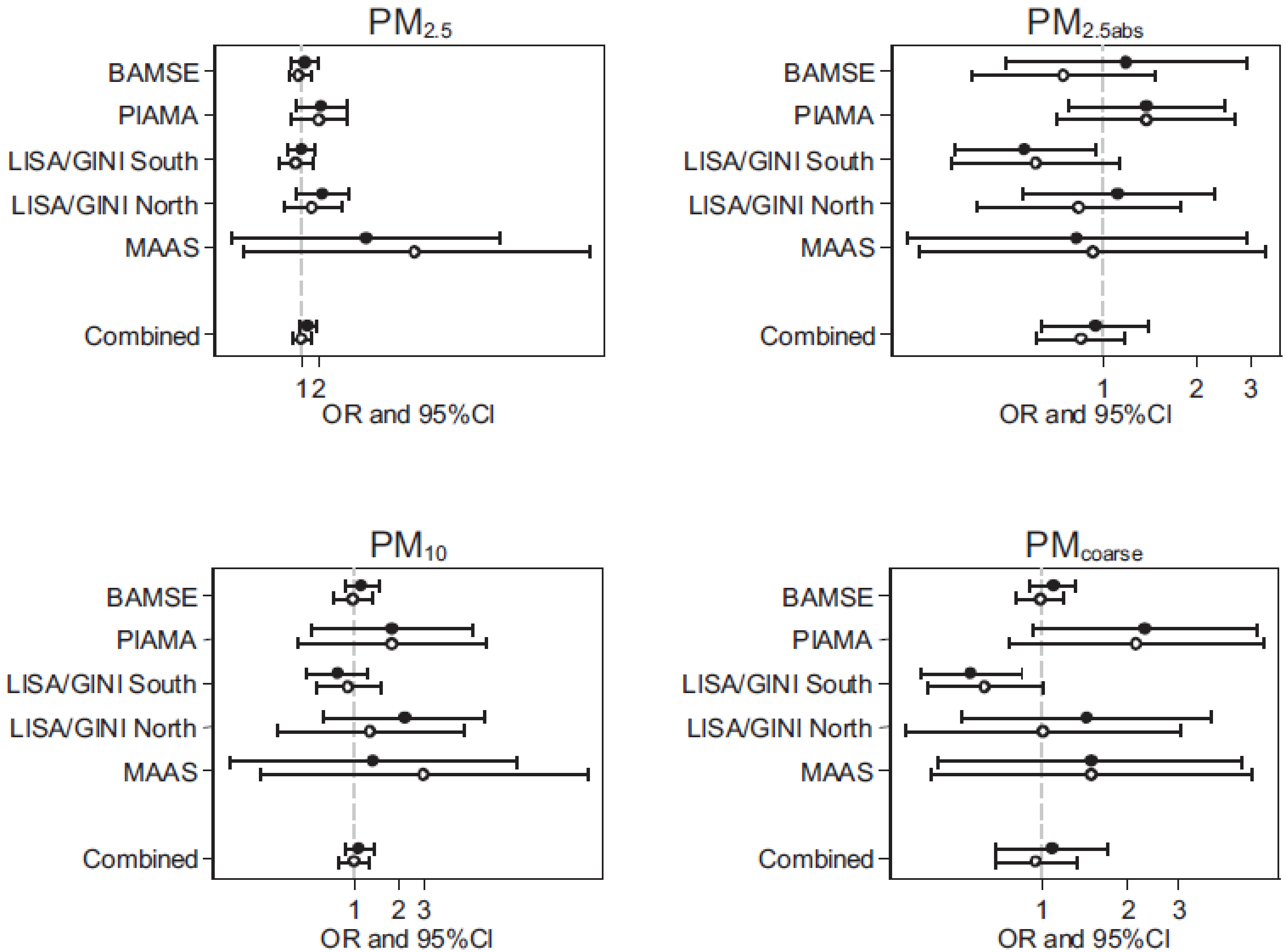
Decrements in lung function

Healthcare use

- **Cause of incident asthma:** PM10 during pregnancy and infancy associated with asthma incidence in birth cohort

Mechanistic framework for air pollution effects in asthma





Gruzieva et al, J Allergy Clin Immunol 2014.

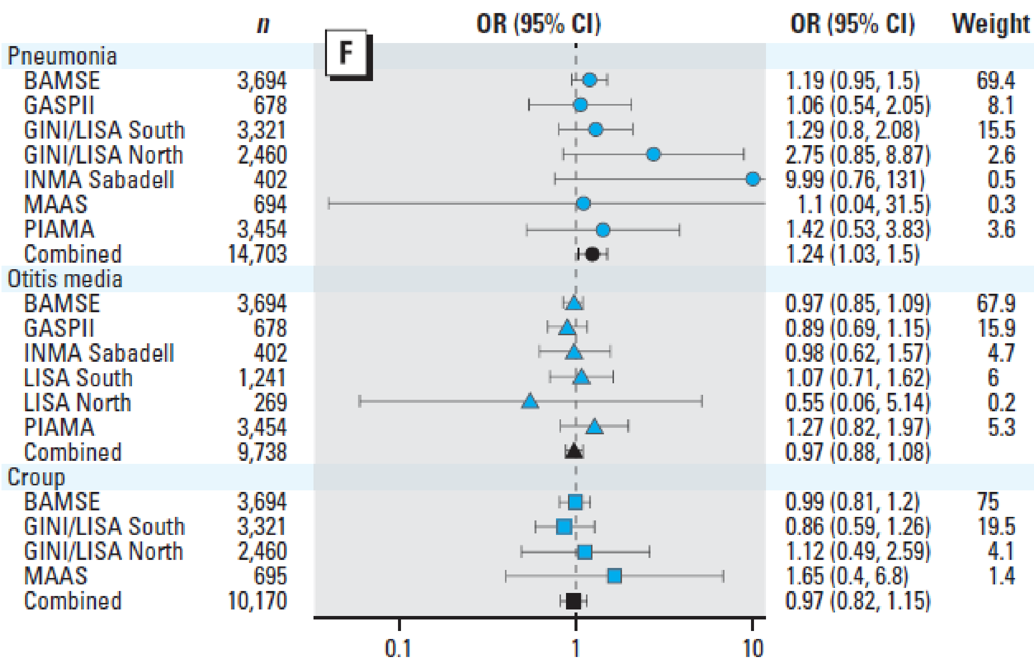
미세먼지와 폐렴

- Air pollution and respiratory infections during early childhood

- 10 European Birth Cohorts (ESCAPE project)
- Air pollution and pneumonia, croup, otitis media

MacIntyre et al. Environ Health Perspect 2014

Risk of pneumonia and PM10



- Adverse effects of outdoor pollution in the elderly
- Review of outdoor pollution and mortality, hospitalization, morbidity in elderly

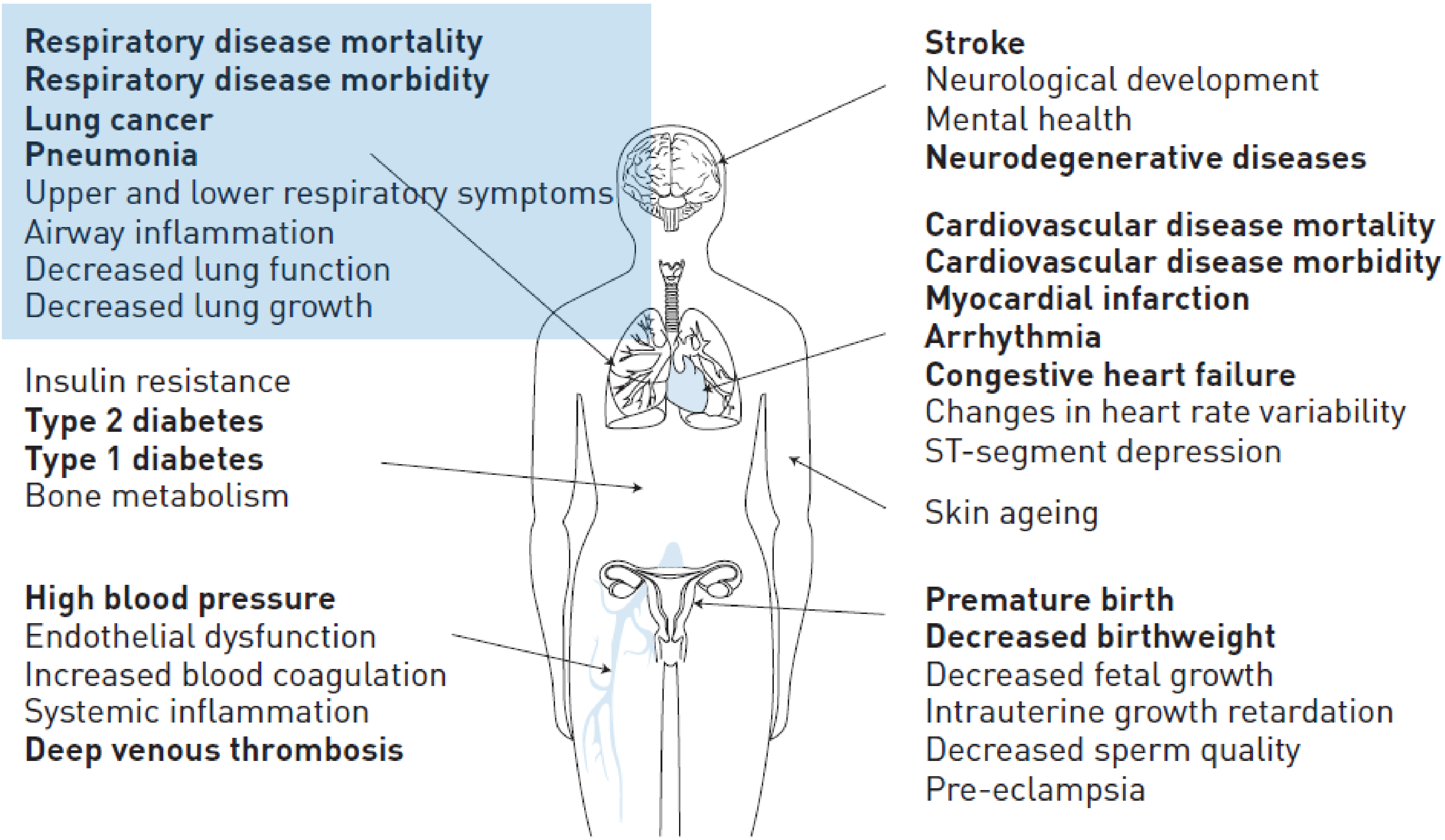
Simoni et al. J Thor Dis 2015

	Pollutants						
	PM_{10}	$PM_{2.5}$	NO_2	SO_2	CO	O_3	BS
Mortality (cardiopulmonary, respiratory)	X	X	X			X	X
Mortality for COPD	X	X	X	X	X		X
Mortality for pneumonia	X		X	X	X	X	
Hospital admission for respiratory diseases	X		X	X	X		
Hospital admission for asthma and COPD	X	X	X	X	X	X	
Hospital admission for pneumonia	X	X	X	X	X	X	
Respiratory symptoms	X		X	X			
Incident COPD	X		X				
Visits for respiratory exacerbation	X	X	X				

Summary

- 장기간의 미세먼지 노출은 소아의 폐기능 성장 저하를, 성인의 폐기능 저하, 폐기능 감소속도 증가를 초래할 수 있으며, 환경 변화에 의해 폐기능 감소 속도는 변화할 수 있다.
- PM10, PM2.5의 증가는 폐암 발생 위험도를 증가시키며, 2013년 IARC/WHO는 미세먼지를 발암물질로 규정하였다.
- 대기 중 PM10 증가는 COPD 악화, 사망률 증가를 초래하며, COPD 발생에 영향을 미칠 수 있다.
- 미세먼지 노출은 단기적으로 알레르기 물질 감작 및 천식 악화와 연관이 있으며, 장기 노출 시 폐기능 감소, 천식 악화 및 병원 이용을 증가시킨다.
- 미세먼지에 노출되면 소아 또는 노인에서 폐렴 발생이 증가할 수 있다.

Overview of diseases condition and biomarkers affected by outdoor air pollution



Thurston et al. Eur Respir J 2017

미세먼지 발생 시 대응법과 근거

질병관리본부 2016

식약처인증 보건용마스크

일반 마스크는 미세먼지 흡입을 막지 못하며, 황사와 미세먼지를 여과할 수 있는 필터가 내장되어 있는 식약처인증 보건용마스크 (KF80, KF94) 또는 N95 마스크는 착용 시 미세먼지 차단 기능이 있다. 또한 제대로 미세먼지를 차단하기 위해서는 올바른 착용이 매우 중요하다.

미세먼지 차단 기능이 있는 마스크 착용 시 미세먼지로부터 건강 피해를 예방할 수 있는지 그 효과에 대한 연구는 많지 않다. 중국연구에서 건강한 사람이 마스크를 쓰면 부분적으로 대기오염 노출이 혈압과 심박변이에 미치는 악영향을 줄일 수 있을 것으로 보고하였고, 관상동맥질환자들도 마스크를 쓰고 다니면 두통, 피곤함, 기침 등의 증상이 감소하고 혈압이 낮아지는 효과가 있어 관상동맥질환의 증상을 줄일 수 있다고 보고하였다. 짧은 외출 시에는 쓸 필요가 없으며, 대기질이 매우 나쁜 상태 (미세먼지 주의보 이상 또는 황사 발생 시)에서 수 시간 외출을 하게 되면 착용이 필요하다. 폐기능이 많이 저하된 환자들이 방역용 (N95) 마스크를 착용하면 호흡곤란 악화, 저산소혈증, 고이산화탄소혈증이 초래될 수 있으므로 권고에 매우 주의해야 한다. 특히 MMRC 호흡곤란점수 3점 이상이거나 1초간 강제호기량 (FEV1)이 30% 미만의 기도폐쇄가 있는 COPD환자는 마스크 착용이 오히려 위험하다. 이는 2, 3기의 임산부에서도 마찬가지로 권고에 신중할 필요가 있다. 외출 전 미리 착용해보고 호흡곤란, 두통, 어지러움 등의 증상이 있으면 즉시 벗도록 권고하는 것이 좋겠다.

참고문헌:

Langrish et al. Part Fibre Toxicol 2009

Langrish et al. Environ Health Perspect 2012

미세먼지/황사로 인한 건강피해 최소화 중재방안 효과 평가 연구. 질병관리본부 2016

공기청정기

대기오염 노출에 따른 폐암 유발인자인 PAHs (polycyclic aromatic hydrocarbons)를 줄이기 위한 중재방안들 중에서 대기청정과 실내공기청정기가 가장 효과적이었으며, 실내 (가정, 학교 등)에서 헤파필터 (high efficacy particulate air filter, HEPA filter)를 사용한 공기청정기가 미세먼지 노출을 줄이는 효과가 있었다. 미세먼지 발생으로 창문을 닫고 주로 실내에서 지내게 될 때 공기청정기를 사용하여 실내대기질을 적절히 유지하는 것이 도움이 될 수 있다.

참고문헌:

Zhou et al. PLoS one 2014
Fisk et al. Indoor Air 2017

비타민, 오메가3 지방산 또는 약물

항산화효과가 있는 비타민 (비타민 C, B6, B12 및 folic acid) 또는 오메가3 지방산이 오존이나 미세먼지에 의한 심폐기능 영향을 일부 줄일 수 있다는 보고가 있고, statin이 미세먼지 노출에 의한 heart rate variability를 개선시켰다는 보고가 있으나 소수의 연구결과로 권고에 무리가 있다.

참고문헌:

Schwartz et al. Am J Respir Crit Care Med 2005
Zhong et al. Sci Rep 2017