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Supplemental Material

Black Carbon as an Additional Indicator of the Adverse Health Effects of Airborne Particles Compared to PM$_{10}$ and PM$_{2.5}$

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Table A1. Estimation of elemental carbon (EC) from black smoke or absorbance of PM$_{2.5}$ filters

| Reference          | Study period | locations                        | Measurement method | R$^a$ | Regression equation slope | Increase in EC per 10 µg/m$^3$ increase in BS$^b$ |
|--------------------|--------------|----------------------------------|--------------------|-------|---------------------------|--------------------------------------------------|
| Edwards et al. 1983 NA | Washington, US; urban + traffic | Thermal optical $^c$          | BS                 | 0.82  | -0.1                      | 1.3                                              |
| Erdman et al. 1993 1989/1990 | Berlin; Germany; urban | VDI 3481 BS                      | BS                 | 0.93  | 0                         | 1.8                                              |
| Schaap et al. 2007 1998/99; 2001/02 | Netherlands, urban | Sunset BS                        | BS                 | 0.92  | 0.32                      | 0.9                                              |
| Kinney et al. 2000 1996 | New York, US urban + traffic | Sunset Abs                       | BS                 | 0.95  | 0                         | 0.8                                              |
| Janssen et al. 2001$^d$ 1997/1998 | Netherlands; urban+traffic | VDI 2465-part 1 Abs             | BS                 | 0.92  | 0                         | 1.7                                              |
| Lena et al. 2002 1999 | New York, US urban + traffic | Sunset Abs                       | NIOSH Abs          | 0.90  | 0                         | 0.5                                              |
| Adams et al. 2002 1999/2000 | London, UK; urban + traffic | Sunset Abs                       | NIOSH Abs          | 0.98  | 0                         | 1.2                                              |
| Cyrys et al. 2003 1999/2000 | Munich, Germany urban+traffic | VDI 2465-part 1 Abs             | BS                 | 0.97  | -1.19                     | 1.6                                              |
| Cyrys et al. 2003 1999/2000 | Netherlands, rural, urban, traffic | VDI 2465-part 1 Abs             | BS                 | 0.97  | -0.26                     | 1.3                                              |
| Cyrys et al. 2003 1999/2000 | Sweden, rural, urban, traffic | VDI 2465-part 1 Abs             | BS                 | 0.85  | 0.36                      | 0.7                                              |

$^a$ coefficient of the correlation between EC and BCP concentrations

$^b$: Results from studies that have used the VDI protocol were divided by 1.25, as this method has been shown to overestimate EC by on average 25% (Schmid et al. 2001); An increase in 1 unit of Abs is considered to equal an increase of 10 µg/m$^3$ BS, according to Roorda-Knape et al. 1998

$^c$ measurement method not further specified

$^d$ paper presents regression equation as Abs = EC; inverse equation, forced through zero, calculated using the original data from the study

|      | Mean$^e$ | Min | Max |
|------|----------|-----|-----|
|      | 1.1      | 0.5 | 1.8 |
Supplement B:

Single city estimates for mortality and hospital admissions in studies that include both PM$_{10}$ and Black Smoke

Table B1.  All cause mortality; all age
(cities in italics occur more than once; city in bold included in meta-analysis)

| Reference       | City         | Estimate PM$_{10}$ | Estimate BS | IQR (µg/m$^3$) | Concentration$^a$ | Corr (R) | Period  | Selected lag$^c$ |
|-----------------|--------------|--------------------|-------------|-----------------|-------------------|-----------|---------|-----------------|
| Verhoeff, 1996  | Amsterdam    | 0.00060            | 0.00038     | 0.00171         | 0.00077           | 22        | 10      | 38              |
| Roemer, 2001    | Amsterdam    | 0.00027            | 0.00020     | 0.00324         | 0.00093           | 18        | 7       | 39              |
| Katsouyanni, 2001 | Athens$^c$  | 0.00153            | 0.00028     | 0.00065         | 0.00012           | NA        | NA      | 40              |
| Katsouyanni, 2001 | Barcelona | 0.00093            | 0.00018     | 0.00157         | 0.00027           | 24$^d$    | 18$^d$  | 60              |
| Katsouyanni, 2001 | Birmingham | 0.00028            | 0.00026     | 0.00034         | 0.00047           | 15$^d$    | 7$^d$   | 21              |
| Katsouyanni, 2001 | Cracow$^e$ | 0.00013            | 0.00035     | -0.00021        | 0.00021           | NA        | NA      | 54              |
| Zeghnoun, 2001a | Le Havre     | 0.00079            | 0.00057     | 0.00026         | 0.00085           | 24        | 12      | 36              |
| Katsouyanni, 2001 | London     | 0.00069            | 0.00017     | 0.00093         | 0.00030           | 14$^d$    | 8$^d$   | 25              |
| Bremner, 1999   | London       | 0.00026            | 0.00023     | 0.00074         | 0.00038           | NA        | NA      | 28              |
| Hoek, 2000      | Netherlands  | 0.00018            | 0.00008     | 0.00040         | 0.00010           | 23$^d$    | 9$^d$   | 34              |
| Zeghnoun, 2001b | Paris        | 0.00066            | 0.00020     | 0.00043         | 0.00015           | 15        | 14      | 22              |
| Katsouyanni, 2001 | Paris      | 0.00043            | 0.00023     | 0.00038         | 0.00015           | 13$^d$    | 15$^d$  | 22              |
| Zeghnoun, 2001a | Rouen        | 0.00024            | 0.00040     | 0.00035         | 0.00083           | 21        | 14      | 33              |
| Anderson, 2001  | Midlands     | 0.00008            | 0.00042     | 0.00036         | 0.00064           | NA        | NA      | 23              |

% change per 10 µg/m$^3$ increase

|                  | %    | 95% CI   | %    | 95% CI   |
|------------------|------|----------|------|----------|
| Pooled Fixed Effects | 0.34 | (0.23-0.47) | 0.52 | (0.37-0.66) |
| Pooled Random Effects | 0.48 | (0.18-0.79) | 0.68 | (0.31-1.06) |
| Heterogeneity chi-squared (df=6) | Q=19.9 | p=0.003 | Q=19.2 | P=0.004 |

$^a$ Mean or median (µg/m$^3$)

$^b$ Coefficient of the correlation between PM$_{10}$ and BS concentrations

$^c$ In case multiple lags were reported in the paper, we used the estimate discussed by the author, as indicated in APED as ‘selected lag’

$^d$ Taken from APHEA II paper on hospital admissions (le Tetre, 2002)

$^e$ Excluded from meta-analyses because PM$_{10}$ was partly derived from BS
Table B2. CVD mortality; all age
(cities in italics occur more than once; city in bold included in meta-analysis)

| Reference     | City                | Estimate PM$_{10}^a$ | Estimate BS | IQR (µg/m$^3$) | Concentration$^a$ | Corr (R) | Period      | Selected lag$^c$ |
|---------------|---------------------|----------------------|-------------|----------------|-------------------|-----------|-------------|------------------|
|               |                     | Beta | SE    | Beta | SE    | PM$_{10}$ | BS | PM$_{10}$ | BS | PM-BS$^b$ |               |             |
| Analitis, 2006| Athens$^e$          | 0.00167 | 0.00045 | 0.00069 | 0.00018 | NA | NA | 40 | 64 | NA | 1992-96 | Lag0-1          |
| Analitis, 2006| Barcelona$^b$       | 0.00055 | 0.00032 | 0.00137 | 0.00050 | 24 | 18 | 60 | 50 | NA | 1991-96 | Lag0-1          |
| Analitis, 2006| Birmingham          | 0.00021 | 0.00040 | 0.00039 | 0.00071 | 15 | 7  | 21 | 11 | NA | 1992-96 | Lag0-1          |
| Analitis, 2006| Cracow$^d$          | 0.00032 | 0.00052 | -0.00007 | 0.00031 | NA | NA | 54 | 36 | NA | 1990-96 | Lag0-1          |
| Zeghnoun, 2001a| Le Havre            | 0.00252 | 0.00126 | 0.00164 | 0.00155 | 24 | 12 | 36 | 16 | 0.70 | 1990-95 | BS lag0-3       |
| Analitis, 2006| London$^e$          | 0.00091 | 0.00028 | 0.00156 | 0.00046 | 14 | 8  | 25 | 11 | NA | 1992-96 | Lag0-1          |
| Bremner, 1999 | London              | 0.00055 | 0.00031 | 0.00117 | 0.00066 | NA | NA | 28 | 13 | NA | 1992-94 | Lag1            |
| Hoek, 2000    | Netherlands         | 0.00019 | 0.00018 | 0.00079 | 0.00020 | 23 | 9  | 34 | 10 | 0.77 | 1986-94 | lag 0-6         |
| Analitis, 2006| Netherlands         | 0.00017 | 0.00016 | 0.00026 | 0.00027 | 23 | 9  | 33 | 9  | NA | 1990-95 | Lag0-1          |
| Hoek, 2001    | Netherlands         | 0.00015 | 0.00018 | 0.00071 | 0.00020 | 23 | 9  | 34 | 10 | 0.77 | 1992/86-1994f | lag 0-6         |
|               |                     |         |       |       |       | NA | NA | 23 | 13 | 0.64 | 1994-96 | Lag0-1          |
| Zeghnoun, 2001b| Paris$^e$           | 0.00086 | 0.00037 | 0.00036 | 0.00029 | 15 | 14 | 22 | 16 | NA | 1990-95 | BS lag 1        |
| Analitis, 2006| Paris$^b$           | 0.00081 | 0.00047 | 0.00063 | 0.00029 | 13 | 15 | 22 | 21 | NA | 1991-96 | Lag0-1          |
| Zeghnoun, 2001a| Rouen$^d$          | 0.00106 | 0.00069 | 0.00276 | 0.00155 | 21 | 14 | 33 | 19 | 0.73 | 1990-95 | Lag1            |
| Anderson, 2001| West Midlands       | 0.00041 | 0.00061 | 0.00089 | 0.00092 | NA | NA | 23 | 13 | 0.64 | 1994-96 | Lag0-1          |

% change per 10 µg/m$^3$ increase

|                  | %  | 95% CI | %  | 95% CI |
|------------------|----|--------|----|--------|
| Pooled Fixed Effects | 0.45 | (0.22-0.68) | 0.73 | (0.41-1.06) |
| Pooled Random Effects | 0.60 | (0.23-0.97) | 0.90 | (0.40-1.41) |

Heterogeneity chi-squared (df=6) Q=9.9, p=0.127 Q=10.2, p=0.116

$^a$ Mean or median (µg/m$^3$)

$^b$ Coefficient of the correlation between PM$_{10}$ and BS concentrations

$^c$ In case multiple lags were reported in the paper, we used the estimate discussed by the author, as indicated in APED as ‘selected lag’

$^d$ Taken from APHEA II paper on hospital admissions (le Tetre, 2002)

$^e$ Excluded from meta-analyses because PM$_{10}$ was partly derived from BS

$^f$ 1992-1994 for PM$_{10}$; 1986-1994 for BS
Table B3. Respiratory mortality; all age
(cities in italics occur more than once; city in bold included in meta-analysis)

| Reference      | City           | Estimate PM$_{10}$ | Estimate BS | IQR (µg/m$^3$) | Concentration$^a$ | Corr (R) PM-BS$^b$ | Period | Selected lag$^c$ |
|----------------|----------------|--------------------|-------------|----------------|-------------------|-------------------|--------|-----------------|
| Analitis, 2006 | Athens$^e$     | 0.00101            | 0.0006      | NA             | 40                | NA                | 1992-96| Lag0-1          |
| Analitis, 2006 | Barcelona$^d$ | 0.00117            | 0.00075     | 24$^d$         | 18$^d$            | 60                | 1991-96| Lag0-1          |
| Analitis, 2006 | Birmingham     | 0.00003            | 0.00078     | 15$^d$         | 7$^d$             | 21                | 1992-96| Lag0-1          |
| Analitis, 2006 | Cracow$^e$    | 0.00529            | 0.00216     | 0.00357        | 0.00132           | NA                | 1990-96| Lag0-1          |
| Zeghnoun, 2001a| Le Havre$^d$  | 0.00200            | 0.00196     | 24             | 12               | 36                | 1990-95| BS lag0-1       |
| Analitis, 2006 | London$^d$     | 0.00022            | 0.00044     | 14$^d$         | 8$^d$             | 25                | 1992-96| Lag0-1          |
| Bremner, 1999  | London         | 0.00128            | 0.00050     | 0.00190        | 0.00084           | NA                | 1992-94| Lag3            |
| Analitis, 2006 | Netherlands    | 0.00031            | 0.00036     | 23$^d$         | 9$^d$             | 33                | 1990-95| Lag0-1          |
| Dab, 1996      | Paris$^d$      | 0.00155            | 0.00059     | 0.00069        | 0.00048           | NA                | 1987-92| PM lag0-1; BS lag0-1 |
| Analitis, 2006 | Paris$^d$      | -0.00121           | 0.00095     | 0.00063        | 0.00029           | NA                | 1991-96| Lag0-1          |
| Zeghnoun, 2001a| Rouen$^d$     | 0.00176            | 0.00120     | 13$^d$         | 15$^d$            | 22                | 1990-95| Lag0-1          |
| Anderson, 2001 | West Midlands  | -0.00058           | 0.00100     | 0.00006        | 0.00153           | NA                | 1994-96| Lag0-1          |

% change per 10 µg/m$^3$ increase

| Pooled Fixed Effects | 0.31 (-0.16-0.78) | 0.70 (-0.05-1.45) |
|----------------------|--------------------|--------------------|
| Pooled Random Effects| 0.31 (-0.23-0.86) | 0.95 (-0.31-2.22) |
| Heterogeneity chi-squared (df=6) | Q=6.9 p=0.329 | Q=12.5 p=0.051 |

$^a$ Mean or median (µg/m$^3$)
$^b$ Coefficient of the correlation between PM$_{10}$ and BS concentrations
$^c$ In case multiple lags were reported in the paper, we used the estimate discussed by the author, as indicated in APED as ‘selected lag’
$^d$ Taken from APHEA II paper on hospital admissions (le Tetre, 2002)
$^e$ Excluded from meta-analyses because PM$_{10}$ was partly derived from BS
### Table B4. Respiratory hospital admissions, age ≥65
(cities in italics occur more than once; city in bold included in meta-analysis)

| Reference          | City         | Estimate PM<sub>10</sub> | Estimate BS | IQR (µg/m<sup>3</sup>) | Concentration<sup>a</sup> | Corr (R) PM-BS<sup>b</sup> | Period   | Selected lag<sup>c</sup> |
|--------------------|--------------|--------------------------|-------------|-------------------------|---------------------------|-----------------------------|----------|--------------------------|
| Atkinson, 2001     | Barcelona    | 0.00198                  | -0.00070    | 0.00083                 | 24                        | 18                          | 56       | 39                       | 1994-96  | Lag0-1                   |
| Atkinson, 2001     | Birmingham   | 0.00090                  | -0.00286    | 0.00115                 | 15                        | 7                           | 25       | 13                       | 1992-94  | Lag0-1                   |
| Prescott, 1998     | Edinburgh    | 0.00208                  | -0.00305    | 0.00338                 | NA                        | NA                          | 21       | 9                        | 1992-95  | Lag1-3                   |
| Atkinson, 2001     | London       | 0.00040                  | -0.00111    | 0.00068                 | 14                        | 8                           | 28       | 13                       | 1992-94  | Lag0-1                   |
| Atkinson, 1999     | London       | 0.00096                  | 0.00082     | 0.00063                 | NA                        | NA                          | 29       | 13                       | 1992-94  | Lag3                      |
| Atkinson, 2001     | Netherlands  | 0.00119                  | 0.00000     | 0.00036                 | 23                        | 9                           | 40       | 13                       | 1992/89- | Lag0-1                   |
|                     |              |                          |             |                         |                           |                             |          |                          | 1995<sup>e</sup> |
| Atkinson, 2001     | Paris        | -0.00010                 | 0.00050     | 0.00046                 | 13                        | 15                          | 23       | 23                       | 1992-96  | Lag0-1                   |
| Anderson, 2001     | West midlands| -0.00045                 | -0.00018    | 0.00100                 | NA                        | NA                          | 23       | 13                       | 1994-96  | Lag0-1                   |

% change per 10 µg/m<sup>3</sup> increase

- pooled fixed effects: 0.85 (0.49-1.20)
- pooled random effects: 0.70 (0.00-1.40)

Heterogeneity chi-squared (df=5) Q=13.1 p=0.023 Q=5.4 p=0.372

### Table B5. Respiratory hospital admissions; Asthma and COPD, age ≥65
(cities in italics occur more than once; city in bold included in meta-analysis)

| Reference          | City         | Estimate PM<sub>10</sub> | Estimate BS | IQR (µg/m<sup>3</sup>) | Concentration<sup>a</sup> | Corr (R) PM-BS<sup>b</sup> | Period   | Selected lag<sup>c</sup> |
|--------------------|--------------|--------------------------|-------------|-------------------------|---------------------------|-----------------------------|----------|--------------------------|
| Atkinson, 2001     | Barcelona    | 0.00257                  | -0.00212    | 0.00116                 | 24                        | 18                          | 56       | 39                       | 1994-96  | Lag0-1                   |
| Atkinson, 2001     | Birmingham   | 0.00050                  | 0.00218     | 0.00199                 | 15                        | 7                           | 25       | 13                       | 1992-94  | Lag0-1                   |
| Atkinson, 2001     | London       | 0.00030                  | 0.00040     | 0.00103                 | 14                        | 8                           | 28       | 13                       | 1992-94  | Lag0-1                   |
| Atkinson, 1999     | London       | 0.00227                  | -0.00091    | 0.00099                 | NA                        | NA                          | 29       | 13                       | 1992-94  | Lag3                      |
| Atkinson, 2001     | Netherlands  | 0.00109                  | 0.00070     | 0.00046                 | 23                        | 9                           | 40       | 13                       | 1992/89- | Lag0-1                   |
|                     |              |                          |             |                         |                           |                             |          |                          | 1995<sup>e</sup> |
| Atkinson, 2001     | Paris        | -0.00660                 | 0.00098     | 0.00020                 | 13                        | 15                          | 23       | 23                       | 1992-96  | Lag0-1                   |

% change per 10 µg/m<sup>3</sup> increase

- pooled fixed effects: 0.95 (0.48-1.42)
- pooled random effects: 0.86 (0.03-1.70)

Heterogeneity chi-squared (df=4) Q=8.3 p=0.08 Q=6.0 p=0.199

<sup>a</sup> Mean or median (µg/m<sup>3</sup>);
<sup>b</sup> Coefficient of the correlation between PM<sub>10</sub> and BS concentrations;
<sup>c</sup> In case multiple lags were reported in the paper, we used the estimate discussed by the author, as indicated in APED as ‘selected lag’
<sup>d</sup> Range in correlation coefficient for all 8 cities described in Atkinson et al (2001) (3 cities not included in this review as no data on black smoke was available)
<sup>e</sup> 1992-1995 for PM<sub>10</sub>; 1989-1995 for BS
Table B6. Respiratory hospital admissions, Asthma, age 0-14  
(cities in italics occur more than once; city in bold included in meta-analysis)

| Reference          | City       | Estimate PM$_{10}$ Beta | SE | Estimate BS Beta | SE | IQR (µg/m$^3$) PM$_{10}$ | BS | Concentration$^a$ PM$_{10}$ | BS | Corr (R) PM-BS | Period | Selected lag |
|--------------------|------------|-------------------------|----|------------------|----|------------------------|----|--------------------------|----|---------------|--------|--------------|
| Atkinson, 2001     | Barcelona  | 0.00266                 | 0.00392 | 0.00989 | 0.00484 | 24 | 18 | 56 | 39 | 0.5-0.8$^a$ | 1994-96 | Lag0-1       |
| Atkinson, 2001     | Birmingham | 0.00276                 | 0.00110 | 0.00199 | 0.00199 | 15 | 7  | 25 | 13 | 0.5-0.8$^a$ | 1992-94 | Lag0-1       |
| Atkinson, 2001     | London     | 0.00060                 | 0.00072 | 0.00109 | 0.00123 | 14 | 8  | 28 | 13 | 0.5-0.8$^a$ | 1992-94 | Lag0-1       |
| Atkinson, 1999     | London     | 0.00324                 | 0.00203 | 0.00245 | 0.00179 | NA | NA | 29 | 13 | 0.6-0.7   | 1992-94 | Lag3        |
| Atkinson, 2001     | Netherlands| -0.00090                | 0.00062 | 0.00139 | 0.00091 | 23 | 9  | 40 | 13 | 0.5-0.8$^a$ | 1992/89. | Lag0-1       |
| Atkinson, 2001     | Paris      | 0.00070                 | 0.00113 | 0.00090 | 0.00087 | 13 | 15 | 23 | 13 | 0.5-0.8$^a$ | 1992-96 | Lag0-1       |
| Anderson, 2001     | West midlands | 0.00797                | 0.00321 | 0.00714 | 0.00329 | NA | NA | 23 | 13 | 0.64      | 1994-96 | Lag0-1       |

% change per 10 µg/m$^3$ increase

Pooled Fixed Effects 0.24 (-0.56-1.05) 1.47 (0.41-2.54)
Pooled Random Effects 0.69 (-0.74-2.14) 1.64 (0.28-3.02)

Heterogeneity chi-squared (df=4) Q=9.5 P=0.050 Q=5.6 p=0.231

Table B7. Respiratory hospital admissions: Asthma, age 15-64  
(cities in italics occur more than once; city in bold included in meta-analysis)

| Reference          | City         | Estimate PM$_{10}$ Beta | SE | Estimate BS Beta | SE | IQR (µg/m$^3$) PM$_{10}$ | BS | Concentration$^a$ PM$_{10}$ | BS | Corr (R) PM-BS | Period | Selected lag |
|--------------------|--------------|-------------------------|----|------------------|----|------------------------|----|--------------------------|----|---------------|--------|--------------|
| Atkinson, 2001     | Barcelona    | 0.00040                 | 0.00202 | 0.00208 | 0.00121 | 24 | 18 | 56 | 39 | 0.5-0.8$^a$ | 1994-96 | Lag0-1       |
| Atkinson, 2001     | Birmingham   | 0.00247                 | 0.00121 | 0.00276 | 0.00239 | 15 | 7  | 25 | 13 | 0.5-0.8$^a$ | 1992-94 | Lag0-1       |
| Atkinson, 2001     | London       | 0.00139                 | 0.00076 | 0.00178 | 0.00137 | 14 | 8  | 28 | 13 | 0.5-0.8$^a$ | 1992-94 | Lag0-1       |
| Atkinson, 1999     | London       | 0.00555                 | 0.00249 | 0.00234 | 0.00224 | NA | NA | 29 | 13 | 0.6-0.7   | 1992-94 | PM Lag3; BS lag2 |
| Atkinson, 2001     | Netherlands  | 0.00040                 | 0.00066 | -0.00040 | 0.00093 | 23 | 9  | 40 | 13 | 0.5-0.8$^d$ | 1992/89-1995 | Lag0-1       |
| Atkinson, 2001     | Paris        | 0.00119                 | 0.00097 | 0.00080 | 0.00076 | 13 | 15 | 23 | 13 | 0.5-0.8$^d$ | 1992-96 | Lag0-1       |
| Anderson, 2001     | West midlands| -0.00233                | 0.00419 | -0.00284 | 0.00432 | NA | NA | 23 | 13 | 0.64      | 1994-96 | Lag0-1       |

% change per 10 µg/m$^3$ increase

Pooled Fixed Effects 0.77 (-0.05-1.61) 0.52 (-0.50-1.55)
Pooled Random Effects 0.77 (-0.05-1.61) 0.52 (-0.50-1.55)

Heterogeneity chi-squared (df=4) Q=2.2 P=0.697 Q=3.1 p=0.549

$^a$ Mean or median (µg/m$^3$); $^b$ Correlation coefficient between PM$_{10}$ and BS concentrations
$^c$ In case multiple lags were reported in the paper, we used the estimate discussed by the author, as indicated in APED as ‘selected lag’
$^d$ Range in correlation coefficient for all 8 cities described in Atkinson et al (2001) (3 cities not included in this review as no data on black smoke was available)
$^e$ 1992-1995 for PM$_{10}$; 1989-1995 for BS
### Table B8. Hospital admissions: Cardiac, age ≥ 65

| Reference       | City        | Estimate PM$_{10}$ | Estimate BS | IQR (µg/m$^3$) | Concentration$^a$ | Corr (R) PM-BS$^b$ | Period | Selected lag$^c$ |
|-----------------|-------------|--------------------|-------------|----------------|-------------------|--------------------|--------|-----------------|
| Le Tertre, 2002 | Barcelona   | 0.00050            | 0.00046     | 0.00666        | 0.00664           | 24 18              | 56 39  | 0.5-0.8$^d$    | 1994-96 | Lag0-1           |
| Le Tertre, 2002 | Birmingham  | -0.00014           | 0.00039     | 0.00114        | 0.00078           | 15 7               | 25 13  | 0.5-0.8$^d$    | 1992-94 | Lag0-1           |
| Le Tertre, 2002 | London      | 0.00104            | 0.00027     | 0.00214        | 0.00049           | 14 8               | 28 13  | 0.5-0.8$^d$    | 1992-94 | Lag0-1           |
| Le Tertre, 2002 | Paris       | 0.00020            | 0.00028     | 0.00057        | 0.00022           | 13 15              | 23 23  | 0.5-0.8$^d$    | 1992-96 | Lag0-1           |
| Anderson, 2001  | West midlands | 0.00030          | 0.00108     | 0.00169        | 0.00117           | NA NA               | 23 13  | 0.64           | 1994-96 | Lag0-1           |

% change per 10 µg/m$^3$ increase

|                |            |                |            |                |                  |                  |       |                |
|----------------|------------|----------------|------------|----------------|------------------|------------------|-------|----------------|
| Pooled Fixed Effects | 0.54 (0.21-0.87) | 0.83 (0.47-1.19) |
| Pooled Random Effects      | 0.51 (0.04-0.98) | 1.07 (0.27-1.89) |
| Heterogeneity chi-squared (df=3) | Q=5.7 p=0.129 | Q=8.8 p=0.032 |

$^a$ Mean or median (µg/m$^3$); $^b$ Coefficient of the correlation between PM$_{10}$ and BS concentrations

$^c$ In case multiple lags were reported in the paper, we used the estimate discussed by the author, as indicated in APED as ‘selected lag’

$^d$ Range in correlation coefficient for all 8 cities described in Le Tertre et al (2002) (no information on cardiac admissions available for the Netherlands; 3 other cities not included in this review as no data on black smoke was available)

### Table B9. Hospital admissions: Cardiac, age ≥ 65

| Reference       | City        | Estimate PM$_{10}$ | Estimate BS | IQR (µg/m$^3$) | Concentration$^a$ | Corr (R) PM-BS$^b$ | Period | Selected lag$^c$ |
|-----------------|-------------|--------------------|-------------|----------------|-------------------|--------------------|--------|-----------------|
| Le Tertre, 2002 | Barcelona   | 0.00068            | 0.00055     | 0.00130        | 0.00075           | 24 18              | 56 39  | 0.5-0.8$^d$    | 1994-96 | Lag0-1           |
| Le Tertre, 2002 | Birmingham  | 0.00031            | 0.00047     | 0.00168        | 0.00094           | 15 7               | 25 13  | 0.5-0.8$^d$    | 1992-94 | Lag0-1           |
| Le Tertre, 2002 | London      | 0.00096            | 0.00032     | 0.00227        | 0.00057           | 14 8               | 28 13  | 0.5-0.8$^d$    | 1992-94 | Lag0-1           |
| Le Tertre, 2002 | Paris       | 0.00053            | 0.00035     | 0.00042        | 0.00027           | 13 15              | 23 23  | 0.5-0.8$^d$    | 1992-96 | Lag0-1           |

% change per 10 µg/m$^3$ increase

|                |            |                |            |                |                  |                  |       |                |
|----------------|------------|----------------|------------|----------------|------------------|------------------|-------|----------------|
| Pooled Fixed Effects | 0.67 (0.28-1.06) | 0.86 (0.41-1.30) |
| Pooled Random Effects      | 0.67 (0.28-1.06) | 1.32 (0.28-2.38) |
| Heterogeneity chi-squared (df=3) | Q=1.5 p=0.673 | Q=9.9 p=0.019 |

$^a$ Mean or median (µg/m$^3$); $^b$ Coefficient of the correlation between PM$_{10}$ and BS concentrations

$^c$ In case multiple lags were reported in the paper, we used the estimate discussed by the author, as indicated in APED as ‘selected lag’

$^d$ Range in correlation coefficient for all 8 cities described in Le Tertre et al (2002) (no information on cardiac admissions available for the Netherlands; 3 other cities not included in this review as no data on black smoke was available)
### Table B10. Hospital admission; IHD, age ≥ 65

(cities in italics occur more than once; city in bold included in meta-analysis)

| Reference                   | City       | Estimate PM$_{10}$ Beta | Estimate BS SE Beta | IQR (µg/m$^3$) PM$_{10}$ BS | Concentration* PM$_{10}$ BS | Corr (R) PM-BS$^b$ | Period     | Selected lag$^c$ |
|-----------------------------|------------|-------------------------|---------------------|-----------------------------|-----------------------------|--------------------|------------|------------------|
| Le Tertre, 2002             | **Barcelona** | -0.00087 0.00087       | 0.00061 0.00120     | 24 18                       | 56 39                       | 0.5-0.8$^d$       | 1994-96    | Lag0-1           |
| Le Tertre, 2002             | Birmingham | 0.00033 0.00076        | -0.00073 0.00150   | 15 7                        | 25 13                       | 0.5-0.8$^d$       | 1992-94    | Lag0-1           |
| Le Tertre, 2002             | **London**  | 0.00104 0.00049        | 0.00265 0.00086     | 14 8                        | 28 13                       | 0.5-0.8$^d$       | 1992-94    | Lag0-1           |
| Atkinson, 1999              | **London**  | 0.00298 0.00128        | 0.00288 0.00119     | NA NA                       | 29 13                       | 0.6-0.7           | 1992-94    | PM lag0; BS Lag3 |
| Le Tertre, 2002             | Netherlands | 0.00036 0.00018        | 0.00100 0.00026     | 23 9                        | 40 13                       | 0.5-0.8$^d$       | 1992/89-1995 | Lag0-1           |
| Le Tertre, 2002             | **Paris**   | 0.00168 0.00057        | 0.00116 0.00043     | 13 15                       | 23 23                       | 0.5-0.8$^d$       | 1992-96    | Lag0-1           |
| Anderson, 2001              | West Midlands | 0.00208 0.00209       | 0.00198 0.00220     | NA NA                       | 23 13                       | 0.64               | 1994-96    | Lag0-1           |

% change per 10 µg/m$^3$ increase

- Pooled Fixed Effects: 0.50 (0.20-0.81) 1.13 (0.72-1.54)
- Pooled Random Effects: 0.68 (0.01-1.36) 1.13 (0.72-1.54)

Heterogeneity chi-squared (df=4): Q=8.8 p=0.066 Q=3.6 p=0.463

*a* Mean or median (µg/m$^3$)

*b* Coefficient of the correlation between PM$_{10}$ and BS concentrations

*c* In case multiple lags were reported in the paper, we used the estimate discussed by the author, as indicated in APED as ‘selected lag’

*d* Range in correlation coefficient for all 8 cities described in Le Tertre et al (2002) (no information on cardiac admissions available for the Netherlands; 3 other cities not included in this review as no data on black smoke was available)
Supplement C: Study specific effect estimates for mortality in studies that include both PM$_{2.5}$ and EC

Table C1. Effect estimates for PM$_{2.5}$ and EC for all cause mortality

| Reference       | City                  | Estimate PM$_{2.5}$ | Estimate EC | IQR | Concentration$^a$ | Corr (R) PM-EC$^b$ | Period      | Selected lag$^c$ |
|-----------------|-----------------------|---------------------|-------------|-----|------------------|-------------------|-------------|------------------|
| Klemm, 2004$^b$| Atlanta               | 0.00544             | 0.01343     | 11.6| 19.6             | 2.0               | 1998-2000   | Lag01            |
| Ostro, 2007$^b$| 6 California counties| 0.00056             | 0.00829     | 14.6| 19.3             | 1.0               | 2000-2003   | Lag3             |
| Cakmak, 2009    | Santiago, Chile       | 0.00212             | 0.01440     | 35.8| NA               | 3.3               | 1998-2006   | PM NA; EC lag1   |

% change per 1 µg/m$^3$ increase$^d$

Pooled Fixed Effects 0.17 (0.13-0.21) 1.45 (1.32-1.57)

Pooled Random Effects 0.19 (0.03-0.35) 1.45 (1.32-1.57)

$^a$ Mean or median; $^b$ Coefficient of the correlation between PM$_{2.5}$ and EC concentrations;

$^d$ Please note that in supplement B the % change was calculated per 10 µg/m$^3$.

Table C2. Effect estimates for PM$_{2.5}$ and EC for cardiovascular mortality

| Reference       | City                  | Estimate PM$_{2.5}$ | Estimate EC | IQR | Concentration$^a$ | Corr (R) PM-EC$^b$ | Period      | Selected lag$^c$ |
|-----------------|-----------------------|---------------------|-------------|-----|------------------|-------------------|-------------|------------------|
| Mar, 2000       | Phoenix               | 0.00685             | 0.04400     | 8.5 | 12.0             | 1.3               | 1995-1997   | Lag1             |
| Ostro, 2007$^b$ | 6 California counties| 0.00105             | 0.02574     | 14.6| 19.3             | 1.0               | 2000-2003   | Lag3             |
| Cakmak, 2009    | Santiago, Chile       | 0.00327             | 0.01736     | 35.8| NA               | 3.3               | 1998-2006   | PM NA; EC lag1   |

% change per 1 µg/m$^3$ increase$^d$

Pooled Fixed Effects 0.26 (0.20-0.32) 1.76 (1.57-1.96)

Pooled Random Effects 0.29 (0.07-0.50) 1.77 (1.08-3.08)

$^a$ Mean or median; $^b$ Coefficient of the correlation between PM$_{2.5}$ and EC concentrations;

$^d$ Please note that in supplement B the % change was calculated per 10 µg/m$^3$.

Table C3. Effect estimates for PM$_{2.5}$ and EC on respiratory mortality

| Reference       | City                  | Estimate PM$_{2.5}$ | Estimate EC | IQR | Concentration$^a$ | Corr (R) PM-EC$^b$ | Period      | Selected lag$^c$ |
|-----------------|-----------------------|---------------------|-------------|-----|------------------|-------------------|-------------|------------------|
| Ostro, 2007$^b$ | 6 California counties| 0.00098             | -0.03298    | 14.6| 19.3             | 1.0               | 2000-2003   | Lag3             |
| Cakmak, 2009    | Santiago, Chile       | 0.00648             | 0.03453     | 35.8| NA               | 3.3               | 1998-2006   | PM NA; EC lag2   |

$^a$ Mean or median; $^b$ Coefficient of the correlation between PM$_{2.5}$ and EC concentrations;

$^d$ Please note that in supplement B the % change was calculated per 10 µg/m$^3$.
Supplement D: Study specific effect estimates for hospital admissions and emergency department visits in studies that include both PM$_{2.5}$ and EC

Table D1. Effect estimates for PM$_{2.5}$, EC and sulfate on hospital admissions and emergency department visits.
(significant effects (p<0.05) in bold)

| Reference | City           | Endpoint     | PM$_{2.5}$ | EC | Sulfate | IQR (µg/m$^3$) | Concentration (µg/m$^3$) |
|-----------|----------------|--------------|------------|----|---------|----------------|--------------------------|
|           |                |              | beta       | se | beta    | beta           | PM$_{2.5}$ | EC | Sulfate | PM$_{2.5}$ | EC | Sulfate |
| **Hospital admissions** | | | | | | | | | | | | |
| Zanobetti, 2006 | Boston; elderly | Pneumonia | 0.0037 | 0.0015 | 0.0540 | 0.0159 | 8.9 | 1.0 | 11.1 | 1.2 |
| Ostro, 2009 | 6 california counties; children | All respiratory | 0.0027 | 0.0008 | 0.0640 | 0.0277 | **0.0199** | 0.0089 | 14.6 | 0.8 | 1.5 | 19.4 | 1.0 | 2.0 |
| Peng, 2009 | 119 US Counties; elderly | CVD | **0.00068** | 0.00021 | **0.01794** | 0.00375 | **0.00140** | 0.00075 | 9.5 | 0.4 | 3.1 | 12.2 | 0.6 | 2.6 |
| Tolbert, 2007 | Atlanta; All age$^a$ | CVD | 0.00046 | 0.00056 | **0.01295** | 0.00439 | -0.00026 | 0.00161 | 11.0 | 1.2 | 3.8 | 17.1 | 1.6 | 4.9 |
| Cakmak, 2009$^b$ | Santiago, Chile; All age | All non-accid. | **0.00152** | 0.00018 | **0.02287** | 0.00184 | **0.02232** | 0.00804 | 40.3 | 4.8 | 2.3 | 40.3 | 2.8 | 2.6 |

$^a$ also estimates from additional endpoints available from 3 older papers that included a shorter study period (Metzger et al. 2004; Sarnat et al. 2008; Tolbert et al. 2000)

$^b$ sulfate estimated from S
Table E1. Effect estimates for EC and other particle components
Effects expressed as % increase per IQR, (significant effects (p<0.05) in bold)

| Reference | City | Endpoint | % increase per IQR | IQR (µg/m³) |
|-----------|------|----------|-------------------|-------------|
|           |      |          | EC    | OC | Sulfate | Nitrate | Zn | K | Si | EC | OC | Sulfate | Nitrate | Zn | K | Si |
| Mortality |      |          |       |    |         |         |    |   |    |     |     |         |         |    |   |    |
| Mar, 2000 | Phoenix | All cause | ns    | ns | -3.0    | ns       | ns | 1.2| 3.0| 0.8 | na  | 0.06   |
|           |       | Cardiovascular | 5.2   | 4.4 |         | ns       | ns | 3.2 |
| Klemm, 2004 | Atlanta | All cause | 1.5   | 1.3 | 3.4     | -0.1     | 1.1| 2.4| 3.9| 1.3 |
| Ostro, 2007 | 6 California counties | All cause | 0.7   | 0.6 | 0.2     | 0.1       | 0.6| 0.2| 0.0 | 0.8| 4.6| 1.5     | 5.5    | 0.01| 0.08| 0.15|
|           |       | Cardiovascular | 2.1   | 1.6 | 0.6     | 1.5       | 2.2| 0.5| 0.6 |     |     |         |         |    |   |    |
|           |       | Respiratory    | -2.6  | -2.9 | 1.1     | 1.0       | -0.5| 0.5| 1.5 |     |     |         |         |    |   |    |
| Maynard, 2007 | Boston | All cause | 2.3   | 1.1 |         | 0.2       |     | 2.3 |     |     |     |         |         |    |   |    |
|           |       | Respiratory    | 3.7   | 2.1 |         |           |     |    |     |     |     |         |         |    |   |    |
|           |       | Cardiovascular | 1.5   | -0.2 |        |           |     |    |     |     |     |         |         |    |   |    |
|           |       | Stroke         | 4.4   | 2.0 |         |           |     |    |     |     |     |         |         |    |   |    |
|           |       | Diabetes       | 5.7   | 2.9 |         |           |     |    |     |     |     |         |         |    |   |    |
| Cakmak, 2009 | Santiago, Chile | All cause | 7.9   | 6.6 | 3.2     | 5.3       | 3.5| 1.7| 5.3| 7.4| 2.8 | 0.08 | 0.23| 0.20|    |
|           |       | Cardiac        | 9.6   | 8.3 | 5.1     | 5.9       | 5.1| 4.2 |     |     |     |         |         |    |   |    |
|           |       | Respiratory    | 20.0  | 17.9 | 6.9     | 13.6      | 11.7| 8.1 |     |     |     |         |         |    |   |    |
| Hospital admission | | | | | | | | | | | | | | | | |
| Ostro, 2009 | 6 California counties; children | All respiratory | 5.4   | 3.4 | 3.0     | 3.3       | 1.6| 0.8| 2.8 |     |     |         |         |    |   |    |
|           |       | Asthma         | 5.3   | 4.0 | 0.4     | 2.4       | 1.8| 0.3| 2.9 | 0.8 | 4.5| 1.5     | 5.6    | 0.01| 0.08| 0.15|
|           |       | Bronchitis     | 4.4   | 4.8 | 6.9     | 3.9       | 1.7| 2.1| 6.1 |     |     |         |         |    |   |    |
|           |       | Pneumonia      | 5.3   | 4.5 | 2.8     | 2.2       | 2.0 | 0.7 | 4.3 |     |     |         |         |    |   |    |
| Peng, 2009 | 119 US counties; elderly | Cardiovascular | 0.7   | 0.7 | 0.4     | 0.5       | 0.2 |     |     | 0.4 | 3.2| 3.1     | 1.6    | 0.07|    |    |
|           |       | Respiratory    | 0.4   | 0.8 | -0.3    | 0.0       | 0.1 |     |     |     |     |         |         |    |   |    |
| Emergency department visits | | | | | | | | | | | | | | | | |
| Sarnat, 2008 | Atlanta; all age | CVD | 2.5   | 2.4 | 0.7     | 0.2       | 1.3| 3.0| 0.8 |     |     |         |         |    |   |    |
|           |       | Respiratory    | -0.4  | -0.3 | 2.0     | -0.1      | -0.3| 0.2| -0.4|     |     |         |         |    |   |    |
| Cakmak, 2009 | Santiago, Chile; all age | All non-accid. | 11.5  | 9.3 | 5.2     | 5.2       | 5.8| 5.8| 4.8 | 8.5| 2.3 | 0.07 | 0.21| 0.18|    |
|           |       | Respiratory    | 18.3  | 14.3 | 7.5     | 7.5       | 9.8 | 11.4|     |     |     |         |         |    |   |    |

*a ns = non-significant (effect estimates not reported in paper)
*b estimates from Sarnat (2008) used instead of Tolbert (2007), despite shorter period (4 instead of 6 years) as the Sarnat paper included more other elements.
*c sulfate estimated from S;
Table E2. Results from single and multi-pollutant models including BCP and sulfate

| Ref. / city | Health endpoint | BCP metric | R Sulfate-BCP | Sulfate single | Sulfate multi | BCP single | BCP multi |
|-------------|-----------------|------------|---------------|----------------|---------------|------------|-----------|
| Hoek, 2000  | Total mortality | BS         | 0.65          | 3.2 (0.6 to 5.9) | 2.7 (-0.3 to 5.8) | 2.8 (1.7 to 3.8) | 1.2 (-1.5 to 4.1) |
|             | CVD mortality   |            |               | 2.1 (-1.9 to 6.3) | 0.8 (-3.7 to 5.4) | 3.2 (1.6 to 4.8) | 2.9 (-1.3 to 7.4) |
| Anderson, 2001; West Midlands | Respiratory admissions | BS | 0.30 | 0.8 (-1.3 to 2.9) | Na | 2.1 (-0.1 to 4.2) | 2.4 (0.1 to 4.7) |
| Maynard, 2007 | Total mortality | BC | 0.44 | 1.1 (0.01 to 2.0) | 0.5 (-0.45 to 1.6) | 2.3 (1.2 to 3.4) | 2.2 (0.2 to 4.2) |
| Peng, 2009; 119 US Counties | Respiratory admissions | EC | 0.18 | -0.3 (-1.1 to 0.5) | -0.6 (-1.1 to 0.3) | 0.4 (-0.1 to 0.9) | 0.0 (-0.1 to 0.8) |
|             | Cardiovascular admissions | | | 0.4 (-0.0 to 0.9) | 0.0 (-0.5 to 0.6) | 0.7 (0.4 to 1.0) | 0.8 (0.3 to 1.3) |
| Cakmak, 2009a; Santiago, Chile | Total mortality | EC | 0.33 | 3.2 (1.4 to 5.0) | Lost significance | 7.9 (7.2 to 8.6) | Remained significantly associated |
|             | Cardiac mortality | | | 5.1 (2.4 to 8.0) | | 9.6 (8.5 to 10.8) | |
|             | Respiratory mortality | | | 6.9 (1.9 to 12.1) | | 20.0 (18.2 to 21.9) | |
| Cakmak, 2009b; Santiago, Chile | All non-accidental adm. | EC | 0.20 | 5.2 (1.5 to 9.1) | Lost significance | 11.5 (9.6 to 13.5) | Remained significant |
|             | Respiratory admissions | | | 7.5 (2.4 to 12.8) | | 18.3 (15.6 to 21.2) | |

\[a\] Coefficient of the correlation between sulfate and BCP concentrations;  
\[b\] RRs expressed as reported in the paper: IQR for Maynard (2007); Peng (2009) and Cakmak (2009a; 2009b); 1 to 9\(^{th}\) percentile for Hoek (2000); 10-90\(^{th}\) percentile for Anderson (2001);  
\[c\] Multi-pollutant estimates also adjusted for OCM, Nitrate, Silicon, Sodium\(_{i\text{on}}\) and Ammonium  
\[d\] Multi-pollutant estimates also adjusted for 16 other PM components and 3 gases; quantitative estimates for multi-pollutant models requested from the authors, but not received
Supplement F:

Effects of PM$_{2.5}$ and BCP in cohort studies of respiratory health in children

### Table F1: Effects of PM$_{2.5}$ and BCP in birth cohort studies

| Reference | Cohort | R PM-BCP $^a$ | RR expressed per | Health endpoint$^b$ | RR PM | RR BCP |
|-----------|--------|---------------|------------------|---------------------|-------|--------|
| Gehring, 2002 | Birth cohort (GINI / LISA) 1756 children born in Munich city Age 2 | 0.96 | Expressed per IQR: PM$_{2.5}$: 1.5 µg/m$^3$ Abs: 0.4 m$^3$ x 10$^{-5}$ | Wheeze | 0.96 | (0.83-1.12) | 0.98 | (0.84-1.14) |
| | | | | Dry cough at night | 1.20 | (1.02-1.42) | 1.16 | (0.98-1.37) |
| | | | | DD obstr/spast/astmoid bronchitis | 0.92 | (0.78-1.09) | 0.94 | (0.79-1.12) |
| | | | | Respiratory infections | 0.98 | (0.80-1.20) | 0.99 | (0.80-1.22) |
| | | | | Sneeze/runny stuffed nose | 0.96 | (0.82-1.12) | 0.92 | (0.78-1.09) |
| Brauer, 2002 | Piama cohort; 3000 children throughout the Netherlands; symptoms at age 2 | 0.99 | Expressed per IQR: PM$_{2.5}$: 3.2 µg/m$^3$ Abs: 0.54 m$^3$ x 10$^{-5}$ | Wheeze | 1.14 | (0.98-1.34) | 1.11 | (0.97-1.26) |
| | | | | DD-asthma | 1.12 | (0.84-1.50) | 1.12 | (0.88-1.43) |
| | | | | Dry cough at night | 1.04 | (0.88-1.23) | 1.02 | (0.88-1.17) |
| | | | | DD bronchitis | 1.04 | (0.85-1.26) | 0.99 | (0.84-1.17) |
| | | | | E,N,T infections | 1.20 | (1.01-1.42) | 1.15 | (1.00-1.33) |
| | | | | DD flu/serious colds | 1.12 | (1.00-1.27) | 1.09 | (0.98-1.21) |
| | | | | Itchy rash | 1.01 | (0.88-1.16) | 1.02 | (0.91-1.15) |
| | | | | DD eczema | 0.95 | (0.83-1.10) | 0.96 | (0.85-1.08) |
| Brauer, 2006 | Birth cohort (Piama); 3000 children throughout the Netherlands Birth cohort (LISA), 600 children from Munich, Germany | 0.99 | Expressed per IQR: PM$_{2.5}$: 3 µg/m$^3$ EC: 0.5 µg/m$^3$ Age 1 | Otitis media | 1.13 | (0.98-1.32) | 1.11 | (0.98-1.26) |
| | | | | Age 2 | 1.13 | (1.00-1.27) | 1.10 | (1.00-1.22) |
| | | | | Expressed per IQR: PM$_{2.5}$: 3 µg/m$^3$ | Otitis media | 1.19 | (0.73-1.92) | 1.12 | (0.83-1.51) |
| | | | | Age 1 | 1.24 | (0.84-1.83) | 1.10 | (0.86-1.41) |
| | | | | Age 2 | 1.24 | (0.84-1.83) | 1.10 | (0.86-1.41) |
| Brauer, 2007 | PIAMA cohort; 3000 children throughout the Netherlands; symptoms at age 4 | 0.99 | Expressed per IQR: PM$_{2.5}$: 3.3 µg/m$^3$ Abs: 0.58 m$^3$ x 10$^{-5}$ | Wheeze | 1.20 | (0.99-1.46) | 1.18 | (1.00-1.40) |
| | | | | DD-asthma | 1.32 | (0.98-1.71) | 1.30 | (0.98-1.71) |
| | | | | Dry cough at night | 1.14 | (0.98-1.33) | 1.14 | (1.00-1.31) |
| | | | | DD bronchitis | 0.86 | (0.66-1.11) | 0.88 | (0.69-1.11) |
| | | | | E,N,T infections | 1.17 | (1.02-1.34) | 1.16 | (1.03-1.31) |
| | | | | DD flu/serious colds | 1.25 | (1.07-1.46) | 1.19 | (1.04-1.37) |
| | | | | Itchy rash | 0.98 | (0.85-1.14) | 0.97 | (0.85-1.10) |
| | | | | DD eczema | 0.98 | (0.82-1.17) | 0.97 | (0.83-1.14) |
| Condition                                      | Morgenstern, 2007 | Expressed per IQR: 0.49 | Morgenstern, 2008 | Expressed per IQR: 0.49 |
|-----------------------------------------------|-------------------|------------------------|-------------------|------------------------|
| GINI / LISA cohort 3577 children residing in the Munich metropolitan area; age 2 | PM$_{2.5}$: 1.0 µg/m$^3$ Abs: 0.22 m$^{-3}$ x $10^{-5}$ | Wheeze | 1.10 (0.96-1.25) | 1.09 (0.90-1.33) |
|                                               |                   | Dry cough at night     |                   | 1.03 (0.89-1.19) |
|                                               |                   | DD obstr/spast/         |                   | 1.05 (0.92-1.20) |
|                                               |                   | astmoid bronchitis     |                   | 0.85 (0.31-2.34) |
|                                               |                   | Respiratory infections |                   | 1.09 (0.94-1.27) |
|                                               |                   | Sneezing/runny stuffed |                   | 1.19 (1.04-1.36) |
|                                               |                   | nose                   |                   | 1.27 (1.04-1.56) |
|                                               |                   | DD obstr/spast/         |                   | 1.05 (0.92-1.20) |
|                                               |                   | astmoid bronchitis     |                   | 0.85 (0.31-2.34) |
|                                               |                   | Respiratory infections |                   | 1.09 (0.94-1.27) |
|                                               |                   | Sneezing/runny stuffed |                   | 1.19 (1.04-1.36) |
|                                               |                   | nose                   |                   | 1.27 (1.04-1.56) |
|                                               |                   | DD obstr/spast/         |                   | 1.05 (0.92-1.20) |
|                                               |                   | astmoid bronchitis     |                   | 0.85 (0.31-2.34) |
|                                               |                   | Respiratory infections |                   | 1.09 (0.94-1.27) |
|                                               |                   | Sneezing/runny stuffed |                   | 1.19 (1.04-1.36) |
|                                               |                   | nose                   |                   | 1.27 (1.04-1.56) |

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* Coefficient of the correlation between PM$_{2.5}$ and BCP concentrations;
* DD = doctor diagnosed; PR = parental report
* Further analyses of Gehring et al. (2002). Here, the study population was expanded by also including subjects who lived outside the Munich area. Although this resulted in a lower correlation between PM$_{2.5}$ and BCP (R=0.49), the performance of the land use regression model used to assign exposure to individual participants was poorer than that of the smaller population (Morgenstern et al. 2007).
Table F2: Effects of PM$_{2.5}$ and BCP in cohort studies on lung function growth

| Reference | Cohort | R PM-BCP | RR expressed per | Health endpoint | RR PM | RR BCP |
|-----------|--------|----------|------------------|----------------|-------|--------|
| Gauderman, 2002 | Results from 2 cohorts | 0.91 | Expressed for concentration range (max - min) PM$_{2.5}$: 22.2 µg/m$^3$ EC: 1.1 µg/m$^3$ | Growth rate FVC (%) | -0.42 (-0.86-0.03) | -0.49 (-0.88-0.09) |
| 1) 1457 children Recruited 1993 4 year follow-up | | | | Growth rate FEV1 (%) | -0.63 (-1.28-0.02) | -0.71 (-1.30-0.12) |
| 2) 1678 children Recruited 1996 4 year follow-up | 0.93 | | | Growth rate MMEF (%) | -0.94 (-1.88-0.01) | -1.07 (-1.94-0.19) |
| | | | Growth rate FVC (%) | -0.14 (-0.67-0.40) | -0.17 (-0.67-0.33) |
| | | | Growth rate FEV1 (%) | -0.39 (-1.06-0.28) | -0.40 (-1.02-0.23) |
| | | | Growth rate MMEF (%) | **-0.94** (-1.87-0.00) | **-0.92** (-1.78-0.05) |
| Gauderman, 2004 | Cohort 1 | 0.91 | Expressed for concentration range (max - min) PM$_{2.5}$: 22.8 µg/m$^3$ EC: 1.1 µg/m$^3$ | Growth rate FVC (ml) | -60.1 (-166.1-45.9) | -77.7 (-166.7-11.3) |
| 8 years follow-up | | | | Growth rate FEV1 (ml) | **-79.7** (-153.0-6.4) | **-87.9** (-146.4-29.4) |
| | | | | Growth rate MMEF (ml) | -168.9 (-345.5-7.8) | **-165.5** (-323.4-7.6) |

* Coefficient of the correlation between PM$_{2.5}$ and BCP concentrations;
Table G1. Contrasts between traffic and background locations for BCP and PM$_{2.5}$

- Ratios and differences values in bold were provided in the paper; values in regular print were calculated from the paper; grey for footnote A

| Reference | Location / period | Site characteristics | Measurement method | Averaging time / # observations | Mean concentration at traffic site$^a$ | Mean concentration at background site$^b$ | Ratio traffic/background |
|-----------|-------------------|----------------------|--------------------|---------------------------------|----------------------------------------|----------------------------------------|-------------------------|
| Janssen, 1997 | Arnhem, The Netherlands / Oct–Nov 1994 | Curbside (0.5 m); 15,000 veh/day; 200 m from nearest busy road | PM$_{2.5}$ mass | 8 h (8:30 – 16:30) 28 paired observations | 42.9 | 51.0 | 35.0 | 22.7 | 1.3 | 2.6 |
| Roorda-Knape, 1998 | Arnhem, The Netherlands / May–Aug 1995 | 1) 15 m from highway; 131,907 veh/day 305 m from the same highway 2) 32 m from highway; 132,559 veh/day | PM$_{2.5}$ mass | 1 week; 10 paired observations 1 week; 8 paired observations | 20.1 | 14.9 | 18.5 | 7.4 | 1.09 | 2.01 |
| Roemer, 2001 | Amsterdam, Netherlands / Jan 1998 – March 1999 | 12-14 m from highway (94,000 veh/day) 7 m from busy street (30,000 veh/day) | PM$_{2.5}$ | 24 h; 65 days with complete information on all 3 sites | 14 | 36 | 10 | 7 | 1.4 | 5.14 |
| Fischer, 2000 | Amsterdam, Netherlands / Jan–Apr 1995 | Outside 18 homes in main streets (5,951-30,974 veh/day) Outside 18 homes in side street (<3,000 veh/day) | PM$_{2.5}$ mass Abs. of PM$_{2.5}$ filters | 24 h; 1-2 samples per home; 18 days with ≥ 1 obs at both types of homes | 12 | 18 | 10 | 7 | 1.2 | 2.57 |
| Janssen, 2001; Smargiassi, 2005 | Outside 24 schools<400m of highways in NL. (1) Apr 1997 - May ‘98; (2) Nov 2001-Oct ’02 | 50 m from busy highway; ±1,400 veh/day; 10% trucks 300 m from highway; ±10,000 veh/day; 17% trucks 200 m from highway; ±100,000 veh/day; 10% trucks | PM$_{2.5}$ mass Abs. of PM$_{2.5}$ filters; Annual average, calculated from 5-10 week measurements per site (adjusted for temporal variation at reference site) | 17.5 (1) | 17.5 (1) | 1.00 (1) | 1.38 (2) | 1.00 (1) | 1.38 (2) | 1.00 (1) | 1.38 (2) | 1.00 (1) | 1.38 (2) |
| Lena, 2002 | New York, USA July – Aug 1999 | Intersection along truck route (515 veh/h; 24% large trucks) Intersection along truck route; highly congested (783 veh/h; 35% large trucks) Intersection along truck route; spacious and open (657 veh/h; 23% large trucks) | Garden of home in residential street; no-truck traffic zone | PM$_{2.5}$ EC estimated from Abs of PM$_{2.5}$ filters (using 12 co-located EC measurements) 10-12h; starting at 6:00 each day; 2-6 samples per traffic site; 9 days at control site (corresponding values at control site calculated from table) | 29.9 | 5.86 | 17.7 | 2.34 | 1.69 | 2.50 |
| Smargiassi, 2005 | Montreal, Canada May – June, YEAR: NA | <10 m of a major urban residential arteries (20,457 veh/day) <10 m of a major urban residential arterie (32,713 veh/day) On a collector artery; 19.137 veh/day on collector; >150,000 on highway | Quiet residential street | PM$_{2.5}$ Abs of PM$_{2.5}$ filter | 24 h; 7 weeks; weekdays only; all sites simultaneously | 13.7 | 1.42 | 12.4 | 1.18 | 1.11 | 1.20 |

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$^a$ PM concentration at traffic site

$^b$ PM concentration at background site
| Reference       | Location / period               | Site characteristics | Measurement method | Averaging time / # observations | Mean concentration at traffic site | Mean concentration at background site | Ratio traffic/background |
|-----------------|--------------------------------|----------------------|-------------------|---------------------------------|----------------------------------|---------------------------------------|------------------------|
| Janssen, 2008   | Munich, Germany March–Dec 2002 | Along highway (30,000 veh/day); 40 m away from another highway (24,000 veh/day) | Suburban residential area | PM$_{2.5}$ Abs. of PM$_{2.5}$ filters; | Annual avg, calculated from 16 week samples per site (adj. for temp variation at ref site) | 15.8 2.60 12.2 1.36 1.30 1.91 |                       |
| Boogaard, 2010  | 8 traffic sites; 9-15 m of busy road in 5 different large cities in the Netherlands; June 2008 – January 2009 | Amsterdam; 15,253 veh/24h; The Hague; 17,438 veh/24h; Den Bosch; 17,896 veh/24h; Den Bosch; 17,138 veh/24h | Urban background site in the same city | PM$_{2.5}$ Abs of PM$_{2.5}$ filter | Six one week measurements Per site; traffic and corresponding background site measured simultaneously | 17.8 4.1 14.8 2.0 1.2 2.1 |                       |
| Kinney, 2000    | New York, USA July, 1996       | Busy intersection; 18,375 cars; 2,467 trucks +buses | Control site in quiet residential area | PM$_{10}$ mass EC | 8 h (10:00-18:00); 5 obs per site; All sites measured simultaneously | 45.7 6.2 38.7 1.5 1.9 1.8 |                       |
| Finasaka, 2000  | Osaka, Japan / Sampling period not specified | Outside 5 homes; <5 m from the road; 27,000-29,000 veh/day | Outside homes 60-150 m from the same roads | PM$_{2.5}$ EC | 7 days; cascade impactors; area B | 27 10 21 6.4 1.29 1.56 |                       |
| Roosli, 2001    | Basel, Switzerland April 1998 – March 1999 | Street canyon near traffic light 18,000 veh/day | Urban background | PM$_{10}$ EC | Annual average; filters every 4th day analysed | 29.9 5.4 21.1 3.0 1.40 1.80 |                       |
| Cyrys, 2003     | Munich / March 1999-2000 6 sites; Average 10 m from traffic | 6 sites; urban background | PM$_{2.5}$ EC and Abs. of PM$_{2.5}$ filters; | Annual average, based on 4-2-week samples per site; adjusted for temporal variation at reference site | 14.3 3.1 13.3 2.1 1.08 1.43 |                       |
| Riediker, 2003  | Raleigh, USA / Aug-Oct 2001 Near major routes; rotating locations | Fixed ambient site | PM$_{2.5}$ EC | Workshift; 7-9 h; 3pm to midnight; 25 days | 29.9 4.0 31.7 1.7 0.94 2.35 |                       |
| Harrison, 2004  | London+Birmingham, UK / April 2000-2001 4 roadside locations; <1 m of kerbside; 27,300-140,400 veh/day | 4 background locations; paired to roadside | PM$_{2.5}$ EC | 24h; 97 complete sets | 22.3 8.4 14.4 2.2 1.6 3.8 |                       |
| Fromme, 2005    | Berlin, Ger-many Feb–June, 2000 | Outside 29-33 apartments 14,000-37,000 cars/day | PM$_{2.5}$ EC | Daytime; 7-8h; 1 obs per home | 32.0 3.4 23.6 2.8 1.36 1.70 |                       |

- Concentrations in µg/m$^3$ for PM, black smoke and EC; concentration in m$^3$x10$^{-3}$ for Absorbance.
- b: Table only includes results of the 4 schools that were measured in both periods; EC derived from regression equation from 47 co-located EC measurements in 1997/98.
- c: Not specified if samples were conducted simultaneously at traffic and background homes (in grey print).
| Reference          | Location / period                  | Measurement method | Difference traffic background (µg/m³) | % EC in roadside increment |
|--------------------|-----------------------------------|--------------------|--------------------------------------|----------------------------|
| Kinney, 2000       | New York, USA; 1996; sidewalk      | EC; sunset         | PM 4.4 BCP 2.6                        | 58                         |
| Funasaka, 2000     | Osaka, Japan / outside homes; period NA | EC                | PM 6.0 BCP 3.6                        | 60                         |
| Janssen, 2001; 2008 | Netherlands; 1997/98; 50 m of highway | EC from Abs<sup>a</sup>; VDI 2465 | PM 2.1 BCP 2.0                        | 76<sup>b</sup>             |
| Lena, 2002         | New York, USA; 1999; sidewalk      | EC from Abs<sup>a</sup>; sunset | PM 6.2 BCP 3.1                        | 50                         |
| Cyrys, 2003        | Munich; 1999/2000                  | EC; VDI 2465       | PM 1.0 BCP 1.0                        | 80<sup>b</sup>             |
| Lena, 2002         | New York, USA; 1999; sidewalk      | EC; VDI 2465       | PM 1.0 BCP 1.0                        | 80<sup>b</sup>             |
| Cyrys, 2003        | Munich; 1999/2000                  | EC; VDI 2465       | PM 2.1 BCP 1.8                        | 69<sup>b</sup>             |
| Janssen, 2008      | Netherlands; 2001/02; 50 m of highway | EC; VDI 2465       | PM 3.6 BCP 1.1                        | 24<sup>b</sup>             |
| Boogaard, 2010     | NL; 2008/09; 9-15 m of busy roads in large cities | Abs of PM<sub>2.5</sub> filters<sup>c</sup> | PM 2.2 BCP 1.6                        | 77                         |

Average includes all studies; average of studies that directly measured EC was 61%.

Note:
- <sup>a</sup> calculated using a study specific calibration derived from co-located samples (see table A1)
- <sup>b</sup> Results from studies that have used the VDI protocol were divided by 1.25, as this method has been shown to overestimate EC by on average 25% (Schmid et al, 2001)
- <sup>c</sup> An increase in 1 unit of Abs is considered to equal an increase of 10 µg/m³ BS, according to Roorda-Knape et al. 1998.
- <sup>d</sup> Average includes all studies; average of studies that directly measured EC was 61%.
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