# 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 EC | Measurement method BCP | R[a] | Regression equation Intercept | Regression equation slope | Increase in EC per 10 μg/m³ increase in BS[b] |
|---|---|---|---|---|---|---|---|---|
| Edwards et al. 1983 | NA | Washington, US; urban + traffic | Thermal optical [c] | BS | 0.82 | -0.1 | 0.13 | 1.3 |
| Erdman et al. 1993 | 1989/ 1990 | Berlin; Germany; urban | VDI 3481 | BS | 0.93 | 0 | 0.23 | 1.8 |
| Schaap et al. 2007 | 1998/99; 2001/02 | Netherlands, urban | Sunset | BS | 0.92 | 0.32 | 0.09 | 0.9 |
| | | Netherlands, rural | Sunset | BS | 0.87 | 0.16 | 0.06 | 0.6 |
| Kinney et al. 2000 | 1996 | New York, US urban + traffic | Sunset | Abs | 0.95 | 0 | 0.83 | 0.8 |
| Janssen et al. 2001[d] | 1997/ 1998 | Netherlands; urban+traffic | VDI 2465-part 1 | Abs | 0.92 | 0 | 2.11 | 1.7 |
| Lena et al. 2002 | 1999 | New York, US urban + traffic | Sunset | Abs | 0.90 | 0 | 0.52 | 0.5 |
| Adams et al. 2002 | 1999/ 2000 | London, UK; urban + traffic | NIOSH | Abs | 0.98 | 0 | 1.21 | 1.2 |
| Cyrys et al. 2003 | 1999/ 2000 | Munich, Germany urban+traffic | VDI 2465-part 1 | Abs | 0.97 | -1.19 | 2.02 | 1.6 |
| Cyrys et al. 2003 | 1999/ 2000 | Netherlands, rural, urban, traffic | VDI 2465-part 1 | Abs | 0.97 | -0.26 | 1.61 | 1.3 |
| Cyrys et al. 2003 | 1999/ 2000 | Sweden, rural, urban, traffic | VDI 2465-part 1 | Abs | 0.85 | 0.36 | 0.90 | 0.7 |
| | | | | | | | **Mean[e]** | **1.1** |
| | | | | | | | **Min** | **0.5** |
| | | | | | | | **Max** | **1.8** |

[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/m³ 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

[e] Mean, minimum and maximum of all 11 values; mean for BS only = 1.16 (range: 0.6-1.8; n=4); mean for Abs only = 1.12 (range0.5-1.7; n=7)

## 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)

| | | Estimate $PM_{10}$ | | Estimate BS | | IQR (µg/m$^3$) | | Concentration[a] | | Corr (R) | Period | Selected |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Reference** | **City** | **Beta** | **SE** | **Beta** | **SE** | **$PM_{10}$** | **BS** | **$PM_{10}$** | **BS** | **PM-BS[b]** | | **lag[c]** |
| Verhoeff, 1996 | *Amsterdam* | 0.00060 | 0.00038 | 0.00171 | 0.00077 | 22 | 10 | 38 | 12 | 0.51 | 1986-92 | Lag0 |
| Roemer, 2001 | *Amsterdam* | 0.00027 | 0.00020 | 0.00324 | 0.00093 | 18 | 7 | 39 | 10 | NA | 1987-94 | Lag1 |
| Katsouyanni, 2001 | Athens[e] | 0.00153 | 0.00028 | 0.00065 | 0.00012 | *NA* | *NA* | 40 | 64 | NA | 1992-96 | Lag0-1 |
| Katsouyanni, 2001 | **Barcelona** | 0.00093 | 0.00018 | 0.00157 | 0.00027 | 24[d] | 18[d] | 60 | 39 | NA | 1991-96 | Lag0-1 |
| Katsouyanni, 2001 | Birmingham | 0.00028 | 0.00026 | 0.00034 | 0.00047 | 15[d] | 7[d] | 21 | 11 | NA | 1992-96 | Lag0-1 |
| Katsouyanni, 2001 | Cracow[e] | 0.00013 | 0.00035 | -0.00021 | 0.00021 | *NA* | *NA* | 54 | 36 | NA | 1990-96 | Lag0-1 |
| Zeghnoun, 2001a | **Le Havre** | 0.00079 | 0.00057 | 0.00026 | 0.00085 | 24 | 12 | 36 | 16 | 0.70 | 1990-95 | PM lag1 / BS lag 0-1 |
| Katsouyanni, 2001 | ***London*** | 0.00069 | 0.00017 | 0.00093 | 0.00030 | 14[d] | 8[d] | 25 | 11 | NA | 1992-96 | Lag0-1 |
| Bremner, 1999 | *London* | 0.00026 | 0.00023 | 0.00074 | 0.00038 | *NA* | *NA* | 28 | 13 | NA | 1992-94 | Lag1 |
| Hoek, 2000 | **Netherlands** | 0.00018 | 0.00008 | 0.00040 | 0.00010 | 23[d] | 9[d] | 34 | 10 | 0.77 | 1986-94 | Lag1 |
| Zeghnoun, 2001b | *Paris* | 0.00066 | 0.00020 | 0.00043 | 0.00015 | 15 | 14 | 22 | 16 | NA | 1990-95 | Lag1 |
| Katsouyanni, 2001 | ***Paris*** | 0.00043 | 0.00023 | 0.00038 | 0.00015 | 13[d] | 15[d] | 22 | 21 | NA | 1991-96 | Lag0-1 |
| Zeghnoun, 2001a | **Rouen** | 0.00024 | 0.00040 | 0.00035 | 0.00083 | 21 | 14 | 33 | 19 | 0.73 | 1990-95 | Lag1 |
| Anderson, 2001 | **West Midlands** | 0.00008 | 0.00042 | 0.00036 | 0.00064 | *NA* | *NA* | 23 | 13 | 0.64 | 1994-96 | Lag0-1 |

| **% change per 10 µg/m$^3$ increase** | **%** | **95% CI** | **%** | **95% CI** |
|---|---|---|---|---|
| Pooled Fixed Effects | 0.34 | (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 $PM_{10}$ Beta | Estimate $PM_{10}$ SE | Estimate BS Beta | Estimate BS SE | IQR (µg/m$^3$) $PM_{10}$ | IQR (µg/m$^3$) BS | Concentration[a] $PM_{10}$ | Concentration[a] BS | Corr (R) PM-BS[b] | Period | Selected lag[c] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Analitis, 2006 | Athens[e] | 0.00167 | 0.00045 | 0.00069 | 0.00018 | *NA* | *NA* | 40 | 64 | NA | 1992-96 | Lag0-1 |
| Analitis, 2006 | **Barcelona** | 0.00055 | 0.00032 | 0.00137 | 0.00050 | 24 [b] | 18 [d] | 60 | 39 | NA | 1991-96 | Lag0-1 |
| Analitis, 2006 | Birmingham | 0.00021 | 0.00040 | 0.00039 | 0.00071 | 15 [b] | 7 [d] | 21 | 11 | NA | 1992-96 | Lag0-1 |
| Analitis, 2006 | Cracow[e] | 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 | PM lag1; BS lag0-3 |
| Analitis, 2006 | ***London*** | 0.00091 | 0.00028 | 0.00156 | 0.00046 | 14 [d] | 8 [d] | 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 [d] | 9 [d] | 34 | 10 | 0.77 | 1986-94 | lag 0-6 |
| Analitis, 2006 | ***Netherlands*** | 0.00017 | 0.00016 | 0.00026 | 0.00027 | 23 [d] | 9 [d] | 33 | 9 | NA | 1990-95 | Lag0-1 |
| Hoek, 2001 | *Netherlands* | 0.00015 | 0.00018 | 0.00071 | 0.00020 | 23 [d] | 9 [d] | 34 | 10 | 0.77 | 1992/86-1994[f] | lag 0-6 |
| Zeghnoun, 2001b | *Paris* | 0.00086 | 0.00037 | 0.00036 | 0.00029 | 15 | 14 | 22 | 16 | NA | 1990-95 | PM lag 2; BS lag 1 |
| Analitis, 2006 | ***Paris*** | 0.00081 | 0.00047 | 0.00063 | 0.00029 | 13 [d] | 15 [d] | 22 | 21 | NA | 1991-96 | Lag0-1 |
| Zeghnoun, 2001a | **Rouen** | 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)

| | | Estimate $PM_{10}$ | | Estimate BS | | IQR (µg/m$^3$) | | Concentration[a] | | Corr (R) | Period | Selected |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Reference** | **City** | **Beta** | **SE** | **Beta** | **SE** | **$PM_{10}$** | **BS** | **$PM_{10}$** | **BS** | **PM-BS[b]** | | **lag[c]** |
| Analitis, 2006 | Athens[e] | 0.00101 | 0.00122 | 0.00006 | 0.00048 | *NA* | *NA* | 40 | 64 | NA | 1992-96 | Lag0-1 |
| Analitis, 2006 | **Barcelona** | 0.00117 | 0.00075 | 0.00374 | 0.00100 | 24 [d] | 18 [d] | 60 | 39 | NA | 1991-96 | Lag0-1 |
| Analitis, 2006 | Birmingham | 0.00003 | 0.00078 | 0.00069 | 0.00130 | 15 [d] | 7 [d] | 21 | 11 | NA | 1992-96 | Lag0-1 |
| Analitis, 2006 | Cracow[e] | 0.00529 | 0.00216 | 0.00357 | 0.00132 | *NA* | *NA* | 54 | 36 | NA | 1990-96 | Lag0-1 |
| Zeghnoun, 2001a | **Le Havre** | 0.00200 | 0.00196 | 0.00249 | 0.00294 | 24 | 12 | 36 | 16 | 0.70 | 1990-95 | PM lag2; BS lag0-1 |
| Analitis, 2006 | ***London*** | 0.00022 | 0.00044 | -0.00034 | 0.00073 | 14 [d] | 8 [d] | 25 | 11 | NA | 1992-96 | Lag0-1 |
| Bremner, 1999 | *London* | 0.00128 | 0.00050 | 0.00190 | 0.00084 | *NA* | *NA* | 28 | 13 | NA | 1992-94 | Lag3 |
| Analitis, 2006 | ***Netherlands*** | 0.00031 | 0.00036 | 0.00029 | 0.00061 | 23 [d] | 9 [d] | 33 | 9 | NA | 1990-95 | Lag0-1 |
| Dab, 1996 | *Paris* | 0.00155 | 0.00059 | 0.00069 | 0.00048 | NA | NA | 51 | 32 | NA | 1987-92 | PM lag0-1; BS lag1 |
| Analitis, 2006 | ***Paris*** | -0.00121 | 0.00095 | 0.00063 | 0.00029 | 13 [d] | 15 [d] | 22 | 21 | NA | 1991-96 | Lag0-1 |
| Zeghnoun, 2001a | **Rouen** | 0.00176 | 0.00120 | 0.00201 | 0.00310 | 21 | 14 | 33 | 19 | 0.73 | 1990-95 | Lag0-1 |
| Anderson, 2001 | **West Midlands** | -0.00058 | 0.00100 | 0.00006 | 0.00153 | *NA* | *NA* | 23 | 13 | 0.64 | 1994-96 | Lag0-1 |
| | | | | | | | | | | | | |
| **% change per 10 µg/m$^3$ increase** | | **%** | **95% CI** | **%** | **95% CI** | | | | | | | |
| Pooled Fixed Effects | | 0.31 | (-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 $PM_{10}$ Beta | Estimate $PM_{10}$ SE | Estimate BS Beta | Estimate BS SE | IQR (μg/m³) $PM_{10}$ | IQR (μg/m³) BS | Concentration[a] $PM_{10}$ | Concentration[a] BS | Corr (R) PM-BS[b] | Period | Selected lag[c] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Atkinson, 2001 | **Barcelona** | 0.00198 | 0.00060 | -0.00070 | 0.00083 | 24 | 18 | 56 | 39 | 0.5-0.8[d] | 1994-96 | Lag0-1 |
| Atkinson, 2001 | Birmingham | 0.00090 | 0.00061 | 0.00286 | 0.00115 | 15 | 7 | 25 | 13 | 0.5-0.8[d] | 1992-94 | Lag0-1 |
| Prescott, 1998 | **Edinburgh** | 0.00208 | 0.00304 | 0.00305 | 0.00338 | NA | NA | 21 | 9 | 0.4 | 1992-95 | Lag1-3 |
| Atkinson, 2001 | ***London*** | 0.00040 | 0.00036 | -0.00111 | 0.00068 | 14 | 8 | 28 | 13 | 0.5-0.8[d] | 1992-94 | Lag0-1 |
| Atkinson, 1999 | *London* | 0.00096 | 0.00041 | 0.00082 | 0.00063 | NA | NA | 29 | 13 | 0.6-0.7 | 1992-94 | Lag3 |
| Atkinson, 2001 | **Netherlands** | 0.00119 | 0.00025 | 0.00000 | 0.00036 | 23 | 9 | 40 | 13 | 0.5-0.8[d] | 1992/89-1995[e] | Lag0-1 |
| Atkinson, 2001 | **Paris** | -0.00010 | 0.00062 | 0.00050 | 0.00046 | 13 | 15 | 23 | 23 | 0.5-0.8[d] | 1992-96 | Lag0-1 |
| Anderson, 2001 | **West midlands** | -0.00045 | 0.00069 | -0.00018 | 0.00100 | *NA* | *NA* | 23 | 13 | 0.64 | 1994-96 | Lag0-1 |
| **% change per 10 μg/m³ increase** | | | | | | | | | | | | |
| Pooled Fixed Effects | | 0.85 | (0.49-1.20) | -0.07 | (-0.58-0.44) | | | | | | | |
| Pooled Random Effects | | 0.70 | (0.00-1.40) | -0.06 | (-0.53-0.41) | | | | | | | |
| 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 $PM_{10}$ Beta | Estimate $PM_{10}$ SE | Estimate BS Beta | Estimate BS SE | IQR (μg/m³) $PM_{10}$ | IQR (μg/m³) BS | Concentration[a] $PM_{10}$ | Concentration[a] BS | Corr (R) PM-BS[b] | Period | Selected lag[c] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Atkinson, 2001 | **Barcelona** | 0.00257 | 0.00080 | -0.00212 | 0.00116 | 24 | 18 | 56 | 39 | 0.5-0.8[d] | 1994-96 | Lag0-1 |
| Atkinson, 2001 | **Birmingham** | 0.00050 | 0.00097 | 0.00218 | 0.00199 | 15 | 7 | 25 | 13 | 0.5-0.8[d] | 1992-94 | Lag0-1 |
| Atkinson, 2001 | ***London*** | 0.00030 | 0.00056 | 0.00040 | 0.00103 | 14 | 8 | 28 | 13 | 0.5-0.8[d] | 1992-94 | Lag0-1 |
| Atkinson, 1999 | *London* | 0.00227 | 0.00137 | -0.00091 | 0.00099 | NA | NA | 29 | 13 | 0.6-0.7 | 1992-94 | Lag 3 |
| Atkinson, 2001 | **Netherlands** | 0.00109 | 0.00030 | 0.00070 | 0.00046 | 23 | 9 | 40 | 13 | 0.5-0.8[d] | 1992/89-1995[e] | Lag0-1 |
| Atkinson, 2001 | **Paris** | -0.00060 | 0.00098 | 0.00020 | 0.00077 | 13 | 15 | 23 | 23 | 0.5-0.8[d] | 1992-96 | Lag0-1 |
| **% change per 10 μg/m³ increase** | | | | | | | | | | | | |
| Pooled Fixed Effects | | 0.95 | (0.48-1.42) | 0.36 | (-0.81-1.54) | | | | | | | |
| Pooled Random Effects | | 0.86 | (0.03-1.70) | 0.22 | (-0.73-1.18) | | | | | | | |
| Heterogeneity chi-squared (df=4) | | Q=8.3 | p=0.08 | Q=6.0 | p=0.199 | | | | | | | |

[a] Mean or median (μg/m³); [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 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 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 | Estimate $PM_{10}$ SE | Estimate BS Beta | Estimate BS SE | IQR (µg/m$^3$) $PM_{10}$ | IQR (µg/m$^3$) BS | Concentration[a] $PM_{10}$ | Concentration[a] 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[c] | 1994-96 | Lag0-1 |
| Atkinson, 2001 | Birmingham | 0.00276 | 0.00100 | 0.00198 | 0.00199 | 15 | 7 | 25 | 13 | 0.5-0.8[c] | 1992-94 | Lag0-1 |
| Atkinson, 2001 | ***London*** | 0.00060 | 0.00072 | 0.00109 | 0.00123 | 14 | 8 | 28 | 13 | 0.5-0.8[c] | 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[c] | 1992/89-1995[e] | Lag0-1 |
| Atkinson, 2001 | **Paris** | 0.00070 | 0.00113 | 0.00090 | 0.00087 | 13 | 15 | 23 | 23 | 0.5-0.8[c] | 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 | Estimate $PM_{10}$ SE | Estimate BS Beta | Estimate BS SE | IQR (µg/m$^3$) $PM_{10}$ | IQR (µg/m$^3$) BS | Concentration[a] $PM_{10}$ | Concentration[a] BS | Corr (R) PM-BS[b] | Period | Selected lag[c] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Atkinson, 2001 | **Barcelona** | 0.00040 | 0.00202 | 0.00208 | 0.00121 | 24 | 18 | 56 | 39 | 0.5-0.8[d] | 1994-96 | Lag0-1 |
| Atkinson, 2001 | Birmingham | 0.00247 | 0.00121 | 0.00276 | 0.00239 | 15 | 7 | 25 | 13 | 0.5-0.8[d] | 1992-94 | Lag0-1 |
| Atkinson, 2001 | ***London*** | 0.00139 | 0.00076 | 0.00178 | 0.00137 | 14 | 8 | 28 | 13 | 0.5-0.8[d] | 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[e] | Lag0-1 |
| Atkinson, 2001 | **Paris** | 0.00119 | 0.00097 | 0.00080 | 0.00076 | 13 | 15 | 23 | 23 | 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] 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 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 $PM_{10}$ Beta | Estimate $PM_{10}$ SE | Estimate BS Beta | Estimate BS SE | IQR (μg/m³) $PM_{10}$ | IQR (μg/m³) BS | Concentration[a] $PM_{10}$ | Concentration[a] BS | Corr (R) PM-BS[b] | Period | Selected lag[c] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Le Tertre, 2002 | **Barcelona** | 0.00050 | 0.00046 | 0.00066 | 0.00064 | 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/m³ 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/m³); [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 $PM_{10}$ Beta | Estimate $PM_{10}$ SE | Estimate BS Beta | Estimate BS SE | IQR (μg/m³) $PM_{10}$ | IQR (μg/m³) BS | Concentration[a] $PM_{10}$ | Concentration[a] BS | 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/m³ 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/m³); [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 $PM_{10}$ SE | Estimate BS Beta | Estimate BS SE | IQR (µg/m³) $PM_{10}$ | IQR (µg/m³) BS | Concentration[a] $PM_{10}$ | Concentration[a] 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[b] | 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/m³ 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/m³)
[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

| | | Estimate $PM_{2.5}$ | | Estimate EC | | IQR | | Concentration[a] | | Corr (R) | Period | Selected lag[c] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Reference** | **City** | **Beta** | **SE** | **Beta** | **SE** | $PM_{2.5}$ | **EC** | $PM_{2.5}$ | **EC** | **PM-EC[b]** | | |
| Klemm, 2004[b] | Atlanta | 0.00544 | 0.00184 | 0.01343 | 0.01072 | 11.6 | 1.1 | 19.6 | 2.0 | NA | 1998-2000 | Lag01 |
| Ostro, 2007[b] | 6 California counties | 0.00056 | 0.00037 | 0.00829 | 0.00776 | 14.6 | 0.8 | 19.3 | 1.0 | 0.53 | 2000-2003 | Lag3 |
| Cakmak, 2009 | Santiago, Chile | 0.00212 | 0.00025 | 0.01440 | 0.00063 | 35.8 | 5.3 | NA | 3.3 | NA | 1998-2006 | PM NA; EC lag1 |
| **% change per 1 μg/m³ increase[c]** | | | | | | | | | | | | |
| 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;
[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] age >65 ; not all age;
[d] please note that in supplement B the % change was calculated per 10 μg/m³

### Table C2. Effect estimates for PM2.5 and EC for cardiovascular mortality

| | | Estimate PM2.5 | | Estimate EC | | IQR | | Concentration[a] | | Corr (R) | Period | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Reference** | **City** | **Beta** | **SE** | **Beta** | **SE** | $PM_{2.5}$ | **EC** | $PM_{2.5}$ | **EC** | **PM-EC[b]** | | **Selected lag[c]** |
| Mar, 2000 | Phoenix | 0.00685 | 0.00236 | 0.04400 | 0.01820 | 8.5 | 1.2 | 12.0 | 1.3 | 0.84 | 1995-1997 | Lag1 |
| Ostro, 2007[b] | 6 California counties | 0.00105 | 0.00054 | 0.02574 | 0.01129 | 14.6 | 0.8 | 19.3 | 1.0 | 0.53 | 2000-2003 | Lag3 |
| Cakmak, 2009 | Santiago, Chile | 0.00327 | 0.00037 | 0.01736 | 0.00097 | 35.8 | 5.3 | NA | 3.3 | NA | 1998-2006 | PM NA; EC lag1 |
| **% change per 1 μg/m³ increase[c]** | | | | | | | | | | | | |
| 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;
[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] age >65 ; not all age;
[d] please note that in supplement B the % change was calculated per 10 μg/m³

### Table C3. Effect estimates for $PM_{2.5}$ and EC on respiratory mortality

| | | Estimate $PM_{2.5}$ | | Estimate EC | | IQR | | Concentration[a] | | Corr (R) | Period | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Reference** | **City** | **Beta** | **SE** | **Beta** | **SE** | $PM_{2.5}$ | **EC** | $PM_{2.5}$ | **EC** | **PM-EC[b]** | | **Selected lag[c]** |
| Ostro, 2007[b] | 6 California counties | 0.00098 | 0.00103 | -0.03298 | 0.02219 | 14.6 | 0.8 | 19.3 | 1.0 | 0.53 | 2000-2003 | Lag3 |
| Cakmak, 2009 | Santiago, Chile | 0.00648 | 0.00058 | 0.03453 | 0.00146 | 35.8 | 5.3 | NA | 3.3 | NA | 1998-2006 | PM NA; EC lag2 |

[a] Mean or median; [b] Coefficient of the correlation between $PM_{2.5}$ and EC 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] age >65 ; not all age;
[d] please note that in supplement B the % change was calculated per 10 μg/m³

## 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/m³) | | | Concentration (µg/m³) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | beta | se | beta | se | beta | se | $PM_{2.5}$ | 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 | |
| | | AMI | **0.0048** | 0.0021 | **0.0391** | 0.0194 | | | | | | | | |
| 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 |
| | | Asthma | 0.0023 | 0.0015 | 0.0628 | 0.0339 | 0.0026 | 0.0199 | | | | | | |
| | | Bronchitis | **0.0034** | 0.0015 | 0.0525 | 0.0341 | **0.0449** | 0.0211 | | | | | | |
| | | Pneumonia | 0.0022 | 0.0014 | 0.0623 | 0.0476 | 0.0182 | 0.0224 | | | | | | |
| 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 |
| | | Respiratory | 0.00031 | 0.00035 | 0.00998 | 0.00599 | 0.00266 | 0.00140 | | | | | | |
| ***Emergency department visits*** | | | | | | | | | | | | | | |
| 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 |
| | | Respiratory | 0.00046 | 0.00047 | -0.00349 | 0.00313 | 0.00183 | 0.00147 | | | | | | |
| 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 | NA | 2.8 | 2.6 |
| | | Respiratory | **0.00241** | 0.00028 | **0.03531** | 0.00247 | **0.03185** | 0.01092 | | | | | | |

[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 ($\mu g/m^3$) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **EC** | **OC** | **Sulfate** | **Nitrate** | **Zn** | **K** | **Si** | **EC** | **OC** | **Sulfate** | **Nitrate** | **Zn** | **K** | **Si** |
| ***Mortality*** | | | | | | | | | | | | | | | | |
| Mar, 2000[a] | 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[a] | 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[b] | Atlanta; all age | CVD | **2.5** | **2.4** | 0.7 | 0.2 | **1.3** | **3.0** | 0.8 | Not available | | | | | | |
| | | Respiratory | -0.4 | -0.3 | **2.0** | -0.1 | -0.3 | 0.2 | -0.4 | | | | | | | |
| Cakmak, 2009[c] | 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[a] | % change in RR[b] 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 | 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) |
| 119 US Counties[c] | 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; | Total mortality | EC | 0.33 | 3.2 ( 1.4 to 5.0) | Lost significance | 7.9 (7.2 to 8.6) | Remained |
| Santiago, Chile[d] | Cardiac mortality | | | 5.1 ( 2.4 to 8.0) | | 9.6 (8.5 to 10.8) | significantly |
| | Respiratory mortality | | | 6.9 (1.9 to 12.1) | | 20.0 (18.2 to 21.9) | associated |
| Cakmak, 2009b; | All non-accidental adm. | EC | 0.20 | 5.2 (1.5 to 9.1) | Lost significance | 11.5 (9.6 to 13.5) | Remained |
| Santiago, Chile[c] | Respiratory admissions | | | 7.5 (2.4 to 12.8) | | 18.3 (15.6 to 21.2) | significant |

[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_ion 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 $m^{-1}$ 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) |
| | | | | Sneezing/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 $m^{-1}$ 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 through-out the Netherlands | 0.99 | Expressed per IQR: $PM_{2.5}$: 3 µg/$m^3$; EC: 0.5 µg/$m^3$ | Otitis media | | | | |
| | | | | Age 1 | 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 |
| | Birth cohort (LISA), 600 children from Munich, Germany | | Expressed per IQR: $PM_{2.5}$: 3 µg/$m^3$; EC: 0.5 µg/$m^3$ | Otitis media | | | | |
| | | | | Age 1 | 1.19 | (0.73- 1.92) | 1.12 | (0.83- 1.51) |
| | | | | 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 $m^{-1}$ 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) |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Morgenstern, 2007[c] | GINI / LISA cohort 3577 children residing in the Munich metropolitan area; age 2 | 0.49 | Expressed per IQR: $PM_{2.5}$: 1.0 µg/m$^3$ Abs: 0.22 m$^{-1}$ x10$^{-5}$ | Wheeze | 1.10 | (0.96-1.25) | 1.09 | (0.90-1.33) |
| | | | | Dry cough at night | 1.03 | (0.89-1.19) | 1.18 | (0.93-1.50) |
| | | | | DD obstr/spast/ astmoid bronchitis | 1.05 | (0.92-1.20) | 0.85 | (0.31-2.34) |
| | | | | Respiratory infections | 1.09 | (0.94-1.27) | 1.05 | (0.79-1.39) |
| | | | | Sneezing/runny stuffed nose | **1.19** | (1.04-1.36) | **1.27** | (1.04-1.56) |
| Morgenstern, 2008[c] | GINI / LISA cohort ±3000 children residing in the Munich metropolitan area; age 4 and 6 | 0.49 | Expressed per IQR: $PM_{2.5}$: 1.0 µg/m$^3$ Abs: 0.22 m$^{-1}$ x10$^{-5}$ | DD obstr/spast/ astmoid bronchitis | 1.12 | (0.94-1.29) | **1.56** | (1.03-2.37) |
| | | | | DD hay fever | 1.01 | (0.91-1.12) | **1.59** | (1.11-2.27) |
| | | | | DD eczema | 1.00 | (0.86-1.24) | 1.03 | (0.86-1.24) |
| | | | | PR obstr/spast/ astmoid bronchitis | 0.97 | (0.91-1.02) | 0.96 | (0.83-1.11) |
| | | | | DD hay fever | 1.02 | (0.96-1.08) | 1.11 | (0.93-1.31) |
| | | | | DD eczema | 1.05 | (0.90-1.37) | 1.05 | (0.93-1.47) |
| | | | | Prevalent asthma | **1.26** | (1.04-1.51) | **1.20** | (1.02-1.42) |
| | | | | Incident asthma | **1.28** | (1.10-1.49) | **1.21** | (1.06-1.38) |
| | | | | Asthma symptoms | **1.15** | (1.02-1.28) | **1.12** | (1.01-1.24) |
| | | | | Wheeze | **1.20** | (1.08-1.33) | **1.16** | (1.06-1.27) |
| | | | | Sneezing, runny/blocked nose | **1.12** | (1.01-1.24) | **1.11** | (1.01-1.21) |
| | | | | Hayfever | 1.05 | (0.83-1.32) | 1.04 | (0.85-1.27) |
| | | | | Atopic eczema | 1.00 | (0.90-1.11) | 1.00 | (0.91-1.10) |
| | | | | ***At age 8 years*** | | | | |
| | | | | Wheeze | **1.29** | (1.04-1.62) | **1.22** | (1.00-1.48) |
| | | | | BHR | 0.98 | (0.76-1.24) | 1.04 | (0.84-1.29) |
| | | | | Allergic sensitization | 1.16 | (0.96-1.39) | 1.12 | (0.95-1.32) |
| | | | | - In utero exposure | **1.02** | (1.00-1.03) | **1.08** | (1.02-1.15) |
| | | | | - First-year exposure | 1.01 | (0.99-1.03) | **1.14** | (1.01-1.29) |

[a] Coefficient of the correlation between $PM_{2.5}$ and BCP concentrations;
[b] DD = doctor diagnosed; PR = parental report
[c] 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[a] | 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$^3$ | | | | | |
| | 1) 1457 children | | | Growth rate FVC (%) | -0.42 | (-0.86- 0.03) | **-0.49** | (-0.88- -0.09) |
| | Recruited 1993 | | | Growth rate FEV1 (%) | -0.63 | (-1.28- 0.02) | **-0.71** | (-1.30- -0.12) |
| | 4 year follow-up | | | Growth rate MMEF (%) | -0.94 | (-1.88- 0.01) | **-1.07** | (-1.94- -0.19) |
| | 2) 1678 children | 0,93 | | Growth rate FVC (%) | -0.14 | (-0.67- 0.40) | -0.17 | (-0.67- 0.33) |
| | Recruited 1996 | | | Growth rate FEV1 (%) | -0.39 | (-1.06- 0.28) | -0.40 | (-1.02- 0.23) |
| | 4 year follow-up | | | Growth rate MMEF (%) | **-0.94** | (-1.87- 0.00) | **-0.92** | (-1.78- -0.05) |
| Gauderman, 2004 | Cohort 1) 8 years follow-up | 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) |
| | | | | 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) |

[a] 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[a] | | Ratio traffic/ background | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Traffic site | Background sites | PM | BCP | | PM | BCP | PM | BCP | PM | BCP |
| Janssen, 1997 | Arnhem, The Netherlands / Oct–Nov 1994 | Curbside (0,5 m); 15,000 veh/day; | Urban; 200 m from nearest busy road | $PM_{2.5}$ mass | Black smoke | 8 h (8:30 – 16:30) 28 paired observations | 42.9 | 51.0 | 35.0 | 22.7 | **1.3** | **2.6** |
| Roorda-Knape, 1998 | Delft (1) and Rotterdam (2), Netherlands / May-aug 1995 | 1) 15 m from highway; 131.907 veh/day | 305 m from the same highway | $PM_{2.5}$ mass | Black smoke | 1 week; 10 paired observations | 20.1 | 14.9 | 18.5 | 7.4 | 1.09 | 2.01 |
| | | 2) 32 m from highway; 132.559 veh/day | 260 m from the same highway | | | 1 week; 8 paired observations | 20.8 | 12.2 | 19.6 | 8.7 | 1.07 | 1.40 |
| Roemer, 2001 | Amsterdam, Netherlands / Jan 1998 – March 1999 | 12-14m from highway (94.000 veh/day) | Urban background site | $PM_1$ TEOM | Black smoke | 24h; 65 days with complete information on all 3 sites | 14 | 36 | 10 | 7 | 1.4 | 5.14 |
| | | 7 m from busy street (30.000 veh/day) | | | | | 12 | 18 | 10 | 7 | 1.2 | 2.57 |
| 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 | 24h; 1-2 samples per home; 18 days with ≥ 1 obs at both types of homes | 25.0 | 2.8 | 21.0 | 1.5 | **1.20** | **1.84** |
| Janssen, 2001; 2008[b] | Outside 24 schools<400m of highways in NL. (1) Apr 1997 - May '98; (2) Nov 2001-Oct '02 | 50 m from busy highway ; ±140.000 veh/day; 10% trucks | 301 (period 1) or 375 (period 2) m distance of highway with low traffic (50.000 veh/day) | $PM_{2.5}$ | Abs. of $PM_{2.5}$ filters; | Annual average, calculated from 5-10 week measurements per site (adjusted for temporal variation at reference site) | 19.6 (1) 17.5 (2) | 1.94 (1) 2.31 (2) | 17.5 (1) 15.1 (2) | 1.00 (1) 1.38 (2) | 1.12 (1) 1.16 (2) | 2.23 (1) 1.81 (2) |
| | | 300 m from highway ; ±110.000 veh/day; 17% trucks | | | | | 21.8 (1) 17.4 (2) | 1.51(1) 1.97 (2) | 17.5 (1) 15.1 (2) | 1.00 (1) 1.38 (2) | 1.25 (1) 1.15 92) | 1.66 (1) 1.51 (2) |
| | | 200 m from highway with; ±100.000 veh/day; 10% trucks | | | | | 17.5 (1) 16.2 (2) | 1.21(1) 1.91 (2) | 17.5 (1) 15.1 (2) | 1.00 (1) 1.38 (2) | 1.00 (1) 1.07 (2) | 1.27 (1) 1.46 (2) |
| Lena, 2002 | New York, USA July – Aug 1999 | Intersection along truck route (515 veh/h; 24% 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 |
| | | Intersection along truck route; highly congested (783 veh/h; 35% large trucks) | | | | | 28.2 | 7.34 | 21.6 | 3.04 | 1.31 | 2.41 |
| | | Intersection along truck route, spacious and open (657 veh/h; 23% large trucks) | | | | | 20.7 | 3.8 | 20.8 | 2.2 | 1.00 | 1.73 |
| Smargiassi 2005 | Montreal, Canada / May – June, YEAR: NA | <10 m of a major urban residential arteries (20.457 veh/day) | Quiet residential street | $PM_{2.5}$ | Abs of $PM_{2.5}$ filter | 24h; 7 weeks; weekdays only; all sites simultaneously | 13.7 | 1.42 | 12.4 | 1.18 | 1.11 | 1.20 |
| | | <10 m of a major urban residential arterie (32.713 veh/day | | | | | 13.4 | 1.63 | 12.4 | 1.18 | 1.08 | 1.38 |
| | | On a collector artery; 19.137 veh/day on collector; >150.000 on highway | | | | | 15.4 | 2.50 | 12.4 | 1.18 | 1.24 | 2.12 |

| Reference | Location / period | Site characteristics | | Measurement method | | Averaging time / # observations | Mean concentration at traffic site[c] | | Mean concentration at background site[c] | | Ratio traffic/ background | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Traffic site** | **Background sites** | **PM** | **BCP** | | **PM** | **BCP** | **PM** | **BCP** | **PM** | **BCP** |
| 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 | 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** |
| | | Amsterdam; 9.774 veh/24h | | | | | 15.1 | 2.7 | 15.1 | 1.6 | **1.0** | **1.7** |
| | | The Hague; 17.438 v/24h; canyon | | | | | 19.4 | 4.4 | 16.2 | 1.6 | **1.2** | **2.7** |
| | | Den Bosch; 17.896 v/24h; canyon | | | | | 18.0 | 3.7 | 13.8 | 1.8 | **1.3** | **2.1** |
| | | Den Bosch; 17.138 veh/24h | | | | | 17.4 | 2.8 | 14.5 | 1.5 | **1.2** | **1.9** |
| | | Tilburg; 18.812 veh/24h | | | | | 17.2 | 2.4 | 15.6 | 1.6 | **1.1** | **1.5** |
| | | Utrecht; 13.553 veh/24h | | | | | 15.4 | 2.1 | 14.0 | 1.4 | **1.1** | **1.5** |
| | | Utrecht; 14.831 veh/24h | | | | | 16.6 | 3.4 | 15.1 | 1.5 | **1.1** | **2.2** |
| Kinney, 2000 | New York, USA July, 1996 | Busy intersection; 18.375 cars; 2.467 trucks +buses | Control site in quiet residential area | $PM_{2.5}$ mass | EC | 8 h (10:00-18:00); 5 obs per site; All sites measured simultaneously | 45.7 | 6.2 | 38.7 | 1.5 | 1.18 | 4.13 |
| | | Bus depot | | | | | 47.1 | 3.7 | 38.7 | 1.5 | 1.22 | 2.47 |
| | | Busy intersection; 14.229 cars; 927 trucks + buses | | | | | 36.6 | 2.3 | 38.7 | 1.5 | 0.95 | 1.53 |
| Funasaka, 2000[c] | 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 | $PM_2$ | EC | 7 days; cascade impactors; area B | 27 | 10 | 21 | 6.4 | 1.29 | 1.56 |
| | | | | | | AND sampler; 48-72 h; average of area A+B (7 homes; 25 obs) | 30 | 9.3 | 24 | 5..7 | 1.25 | 1.62 |
| 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 4[th] day analysed | 29.9 | 5.4 | 21.1 | 3.0 | 1.40 | 1.80 |
| Cyrys, 2003 | Munich / March 1999-July 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** |
| | Netherlands; Mar 1999-April 2000 | 4 sites, average 6 m from traffic | 4 sites; urban background | | | | 19.9 | 3.9 | 17.8 | 2.1 | **1.12** | **1.84** |
| | Stockholm / Feb 1999-Mar 2000 | 2 sites, average 19 m from traffic | 7 sites; urban background | | | | 13.8 | 2.5 | 10.2 | 1.4 | **1.35** | **1.79** |
| 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+Birming-ham, UK / April 2000 – Jan, 2002 | 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[c] | Berlin, Ger-many / Feb –June, 2000 | Outside 29-33 apartments 14.000-37.000 cars/day | 21-23 apartments 100-900 cars/day | $PM_4$ | EC | Daytime; 7-8h; 1 obs per home | 32.0 | 3.4 | 23.6 | 2.8 | 1.36 | 1.70 |

[a] Concentrations in µg/m³ for PM, black smoke and EC; concentration in $m^{-1}x10^{-5}$ 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)

**Table G2. Estimated percentage EC in the roadside increment of $PM_{2.5}$**

| Reference | Location / period | Measurement method BCP | Difference traffic – background (µg/m³) PM | BCP | % EC in roadside increment | | |
|---|---|---|---|---|---|---|---|
| Kinney, 2000 | New York, USA; 1996 ; sidewalk | EC; sunset | 4.4 | 2.6 | 58 | | |
| Funasaka, 2000 | Osaka, Japan / outside homes; period NA | EC | 6.0 | 3.6 | 60 | | |
| Janssen, 2001; 2008 | Netherlands; 1997/98; 50 m of highway | EC from Abs[a]; VDI 2465 | 2.1 | 2.0 | 76 [b] | | |
| Lena, 2002 | New York, USA; 1999; sidewalk | EC from Abs[a]; sunset | 6.2 | 3.1 | 50 | | |
| Cyrys, 2003 | Munich; 1999/ 2000 | EC; VDI 2465 | 1.0 | 1.0 | 80 [b] | | |
| | Netherlands;1999/ 2000 | EC; VDI 2465 | 2.1 | 1.8 | 69 [b] | | |
| | Sweden; 1999 / 2000 | EC; VDI 2465 | 3.6 | 1.1 | 24 [b] | | |
| Harrison, 2004 | London+Birmingham, UK; 2000/02; roadside | EC | 8.4 | 6.1 | 69 | | |
| | | | | | **10 µg/m³ BS = 1.1µg/m³ EC** | **10 µg/m³ BS = 0.5µg/m³ EC** | **10 µg/m³ BS = 1.8µg/m³ EC** |
| Janssen, 1997 | Arnhem, NL; Oct–Nov 1994; curbside | Black smoke | 7.9 | 28.3 | 39 | 18 | 64 |
| Roorda-Knape, 1998 | NL / May-aug 1995; 15-32 m of highways | Black smoke | 1.4 | 5.5 | 43 | 20 | 71 |
| Roemer, 2001 | Amsterdam, NL; 1998/99; 7 m of busy street | Black smoke | 2.0 | 11.0 | 61 | 28 | 99 |
| Fischer, 2000 | Amsterdam, Netherlands / 1995; outside homes | Abs of $PM_{2.5}$ filters[c] | 3.0 | 1.3 | 47 | 22 | 77 |
| Smargiassi, 2005 | Montreal, Canada; curbside or on collector | Abs of $PM_{2.5}$ filters[c] | 1.8 | 0.7 | 42 | 19 | 68 |
| Janssen, 2008 | Netherlands; 2001/02; 50 m of highway | Abs of $PM_{2.5}$ filters[c] | 2.4 | 0.9 | 43 | 19 | 70 |
| Janssen, 2008 | Munich, Germany ; 2002; along highway | Abs of $PM_{2.5}$ filters[c] | 3.6 | 1.2 | 38 | 17 | 62 |
| Boogaard, 2010 | NL; 2008/09; 9-15 m of busy roads in large cities | Abs of $PM_{2.5}$ filters[c] | 2.2 | 1.6 | 77 | 35 | 127 |
| | | | | **Average[d]** | **55%** | **41%** | **70%** |
| | | | | **95% CI** | **46-63** | **29-54** | **59-82** |

[a] calculated using a study specific calibration derived from co-located samples (see table A1)
[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)
[c] 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.
[d] Average includes all studies; average of studies that directly measured EC was 61%.

## References


Adams HS, Nieuwenhuijsen MJ, Colvile RN, Older MJ, Kendall M. 2002. Assessment of road users' elemental carbon personal exposure levels, London, UK. Atmospheric Environment 36:5335-5342.

Analitis A, Katsouyanni K, Dimakopoulou K, et al. 2006. Short-term effects of ambient particles on cardiovascular and respiratory mortality. Epidemiology 17:230233.

Anderson HR, Bremner SA, Atkinson RW, Harrison RM, Walters S. 2001. Particulate matter and daily mortality and hospital admissions in the west midlands conurbation of the United Kingdom: associations with fine and coarse particles, black smoke and sulphate. Occup Environ Med 58:504-510.

Atkinson RW, Anderson HR, Strachan DP, Bland JM, Bremner SA, Ponce de Leon A. 1999a. Short-term associations between outdoor air pollution and visits to accidents and emergency departments in London for respiratory complaints. Eur Respir J 13:257-265.

Atkinson RW, Bremner SA, Anderson HR, Strachan DP, Bland JM, de Leon AP. 1999b. Short-term associations between emergency hospital admissions for respiratory and cardiovascular disease and outdoor air pollution in London. Arch Environ Health 54:398-411.

Atkinson RW, Anderson HR, Sunyer J, et al. 2001. Acute effects of particulate air pollution on respiratory admissions. Am J Respi Crit Care Med 2001;164:1860-1866.

Behndig AF, Mudway IS, Brown JL, Stenfors N, Helleday R, Duggan ST, et al. 2006. Airway antioxidant and inflammatory responses to diesel exhaust exposure in healthy humans. Eur Respir J 27:359-365.

Boogaard H, Kos GPA, Weijers E, Janssen NAH, Fischer PH, van der Zee S, et al. 2011. Contrast in air pollution components between major streets and background locations: particulate matter mass, black carbon, elemental composition, nitrogen oxide and ultrafine particle number. Atmospheric Environment 45:650-658.

Brauer M, Hoek G, van Vliet P, Meliefste K, Fischer PH, Wijga A, et al. 2002. Air pollution from traffic and the development of respiratory infections and asthmatic and allergic symptoms in children. Am J Respir Crit Care Med 166:1092-1098.

Brauer M, Gehring U, Brunekreef B, de Jongste J, Gerritsen J, Rovers M, et al. 2006. Traffic-related air pollution and otitis media. Environ Health Pespect 114:1414-1418.

Brauer M, Hoek G, Smit HA, de Jongste JC, Gerritsen J, Postma DS. 2007. Air pollution and development of asthma, allergy and infections in a birth cohort. Eur J Respir 29:879-888.

Bremner SA, Anderson HR, Atkinson RW, McMichael AJ, Strachan DP, Bland JM, et al. 1999. Short term associations between outdoor air pollution and mortality in London 1992-4. Occup Environ Med 56:237-244.

Cakmak S, Dales RE, Blanco Vida C. 2009a. Components of particulate air pollution and mortality in Chile. Int J Occup Environ Health 15:152-158.

Cakmak S, Dales R, Gultekin T, Vidal CB, Farnendaz M, Rubio MA, et al. 2009b. Components of particulate air pollution and emergency department visits in Chile. Arch Environ Occup Health 64:148-155.

Cancado JED, Saldiva PHN, Pereira LAA, et al. 2006. The impact of sugar cane-burning emissions on the respiratory system of children and the elderly. Environ Health Perspect 115:725-729.

Cyrys J, Heinrich J, Hoek G, Meliefste K, Lewne M, Gehring U, et al. 2003. Comparison between different traffic-related particle indicators: Elemental carbon (EC), $PM_{2.5}$ mass, and absorbance. J Expo Anal Environ Epidemiol 13:134-143.

Dab W, Medina S, Quenel P, et al. 1995. Short term respiratory health effects of ambient air pollution: results of the APHEA project in Paris. J Epidemiol Comm Health 1996;50(Suppl 1):S42-S46.

Edwards JD, Ogren JA, Weiss JE, Charlson RJ. 1983. Particulate air pollutants: A comparison of British “Smoke” with optical absorption coefficient and elemental carbon concentration. Atmospheric Environment 17:2337-2341.

Fischer PH, Hoek G, van Reeuwijk H, Briggs DJ, Lebret E, van Wijnen JH, et al. 2000. Traffic-related differences in outdoor and indoor concentrations of particles and volatile organic compounds in Amsterdam Atmospheric Environment 34:3713-3722.

Fromme H, Lahrz T, Hainsch A, Oddoy A, Piloty M, Ruden H. 2005. Elemental carbon and respirable particulate matter in the indoor air of apartments and nursery schools and ambient air in Berlin (Germany). Inddor Air 15:335-341.

Funasaka K, Miyazaki T, Tsuruho K, Tamura K, Mizuno T, Kuroda K. 2000. Relationship between indoor and outdoor carbonaceous particulates in roadside households. Environ Poll 110:127-134.

Gauderman WJ, Gilliland F, Vora H, Avol E, Stram D, McDonnel R, et al. Association between air pollution and lung function growth in southern california children. 2002. Am J Crit Care Med 166:76-84.

Gauderman WJ, Avol E, Gilliland F, Vora H, Thomas D, Berhane K, et al. 2004. The effects of air pollution on lung development from 10 to 18 years of age. N Engl Med 351:1057-1067.

Gehring U, Cyrys J, Sedlmeir G, Brunekreef B, Bellander T, Fischer P, et al. 2002. Traffic-related air pollution and respiratory health during the First 2 yrs of life. Eur Respir J 19:690-698.

Harrison RM, Jones AM, Lawrence RG. 2004. Major component composition of $PM_{10}$ and $PM_{2.5}$ from roadside and urban background sites. Atmospheric Environment 38:4531-4538.

Hoek G, Brunekreef B, Verhoeff A, van Wijnen J, Fischer P. 2000. Daily mortality and air pollution in the Netherlands. J Air Waste Manage Assoc 50:1380-1389.

Hoek G, Brunekreef B, Fischer P, van Wijnen J. 2001. The association between air pollution and heart failure, arrhythmia, embolism, thrombosis, and other cardiovascular causes of death in a time series study. Epidemiology 12:355-357.

Janssen NAH, van Mansom DFM, van der Jagt K, Harssema H, Hoek G. 1997. Mass concentration and elemental composition of airborne particulate matter at street and background location. Atmospheric Environment 31:1185-1193.

Janssen NAH, van Vliet PHN, Aarts F, Harssema H, Brunekreef B. 2001. Assessment of exposure to traffic related air pollution of children attending schools near motorways. Atmospheric Environment 35:3875-3884.

Janssen NAH, Meliefste K, Fuchs O, Weiland SK, Cassee F, Brunekreef B, Sandstrom T 2008. High and low volume sampling of particulate matter at sites with different traffic profiles in the Netherlands and Germany: Results from the HEPMEAP study. Atmospheric Environment 42:1110-1120.

Katsouyanni K, Touloumi G, Samoli E, et al. 2001. Confounding and effect modification in the short-term effects of ambient particles on total mortality: results from 29 cities within the APHEA2 project. Epidemiology 12:521-531.

Kinney PL, Aggarwal M, Northridge ME, Janssen NA, Shepard P. 2000. Airborne concentrations of PM(2.5) and diesel exhaust particles on Harlem sidewalks: a community-based pilot study. Environ Health Perspect 108:213-218.

Klemm RJ, Lipfert FW, Wyzga RE, Gust C. 2004. Daily mortality and air pollution in Atlanta: two years of data from ARIES. Inhal Tox 16(suppl 1):131-141.

Lena TS, Ochieng V, Carter M, Holguin-Veras J, Kinney PL. 2002. Elemental Carbon and $PM_{2.5}$ levels in an urban community heavily impacted by truck traffic. Environ Health Perspect 110:1009-1015.

Le Tertre A, Medina S, Samoli E, Forsberg B, Michelozzi P, Boumghar A, et al. 2002. Short-term effects of particulate air pollution on cardiovascular disease in eight European cities. J Epidemiol Comm Health 56:773-779.

Mar TF, Norris GA, Koenig JQ, Larson TV. 2000. Associations between air pollution and mortality in Phoenix, 1995-1997. Environ Health Perspect 108:347-353.

Maynard D, Coull BA, Gryparis A, Schwartz J. 2007. Mortality risk associated with short-term exposure to traffic particles and sulfates. Environ Health Perspect 115:751-755.

Metzger KB, Tolbert PE, Klein M, et al. 2004. Ambient Air pollution and cardiovascular emergency department visits. Epidemiology 15:46-56.

Morgenstern V, Zutavern A, Cyrys J, Brockow I, Gehring U, Koletzko S, et al. 2007. Respiratory health and individual estimated exposure to traffic-related air pollutants in a cohort of young children. Occup Environ Med 64:8-16.

Morgenstern V, Zutavern A, Cyrys J, Brockow I, Koletzko S, Kramer U. 2008. Atopic diseases, allergic sensitization, and exposure to traffic-related air pollution in children. Am J Crit Car Med 177:1331-1337.

Ostro B, Feng WY, Broadwin R, Green S, Lipsett M. 2007. The effects of components of fine particulate air pollution on mortality in California: Results from CALFINE. Environ Health Perspect 15:13-19.

Ostro B, Roth L, Malig B, Marty M. 2009. The effects of fine particle components on respiratory hospital admissions in children. Environ Health Perspect 117:475-480.

Peng RD, Bell ML, Geyh AS, McDermott A, Zeger SL, Samet JM, et al. 2009. Emergency admissions for cardiovascular and respiratory diseases and the chemical composition of fine particle air pollution. Environ Health perspect 117:957-963.

Prescott GJ, Cohen GR, Elton RA, et al. 1998. Urban air pollution and cardiopulmonary ill health: a 14,5 year time series study. Occup Envion Med 55:697-704.

Riediker M, Williams R, Devlin R, Griggs T, Bromberg P. 2003. Exposure to particulate matter, volatile organic compounds, and other air pollutants inside patrol cars. Environ Sci Technol. 37:2084-93.

Roemer WH, van Wijnen JH. 2001a. Daily mortality and air pollution along busy streets in Amsterdam, 1987-1998. Epidemiology 12:649-653.

Roemer WH, van Wijnen JH. 2001b. Differences among black smoke, PM(10), and PM(1.0) levels at Urban Measurement Sites. Environ Health Perspect 109:151-4.

Roorda-Knape M, Janssen NAH, de Hartog JJ, van Vliet PHN, Harssema H, Brunekreef B. 1998. Air pollution from traffic in city districts near major motorways. Atmospheric Environment 32:1921-1930.

Sarnat JA, Marmur A, Klein M, Kim E, Russell AG, Sarnat SE, et al. 2008. Fine particle sources and cardiorespiratory morbidity: an application of chemical mass balance and factor analytical source-apportionment methods. Environ Health Perspect 116:459-466.

Schaap M, van der Gon HAC. 2007. On the variability of black smoke and carbonaceous aerosols in the Netherlands. Atmospheric Environment 41:5908-5920.

Schmid H, Laskus L, Abraham HJ, Baltensperger U, Lavanchy V, Bizjak M, et al. 2001. Results of the 'Carbon conference' international aerosol carbon round robin test stage 1. Atmospheric Environment 35:2111-2121.

Smargiassi A, Baldwin M, Pilger C, Dugandzic R, Brauer M. 2005. Small scale spatial variability of particle concentration and traffic levels in Montreal: a pilot study. Sci Tot Environ 338:243-251.

Tolbert PE, Klein M, Metzger KB, et al. 2000. Interim results of the study of particulates and health in Atlanta (SOPHIA). J Expo Anal Environ Epidemiol 10:446-460.

Tolbert PE, Klein M, Peel JL, Sarnat SE, Sarnat JA. 2007. Multipollutant modeling issues in a study of ambient air quality and emergency department visits in Atlanta. J Expo Sci Environ Epidemiol 7:S29-S35.

Verhoeff AP, Hoek G, Schwartz J, van Wijnen JH. 1996. Air pollution and daily mortality in Amsterdam. Epidemiology 1996;7:225-230.

Zanobetti A, Schwartz J. 2006. Air pollution and emergency admissions in Boston, MA. J Epidemiol Commun Health 60:890-895.

Zeghoun A, Czernichow P, Beaudeau P, et al. 2001a. Short-term effects of air pollution on mortality in the cities of Rouen and Le Havre, France, 1990-1995. Arch Environ Health 56:327-335.

Zeghoun A, Eilstein D, Saviuc P, et al. 2001b. Surveillance des effets a court terme de la pollution atmosphérique sur la mortalité en milieu urbain. Résultats d'une étude de faisabilité dans 9 villes francaises. Revue d'Epidemiol et de Sante Publique 49:3-12.