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Supplemental Material

Hourly Exposure to Ultrafine Particle Metrics and the Onset of Myocardial Infarction in Augsburg, Germany

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Table S1. Percent difference (95% CI) in hourly cases of myocardial infarction (MI) per interquartile range increase in particle metrics in Augsburg, Germany, from 2005 to 2015.

| Lag hour | PNC ₁₀₋₃₀ | PNC ₃₀₋₁₀₀ | PNC ₁₀₋₁₀₀ | PNC ₁₀₀₋₅₀₀ | PLC | PSC ^a | PM _{2.5} | PM ₁₀ |
|----------|------------------------|-------------------------|------------------------|------------------------|------------------------|-------------------------|------------------------|------------------------|
| 0 | -0.48 (-2.09, 1.15) | -0.03 (-2.89, 2.91) | -0.56 (-2.79, 1.71) | 1.86 (-1.58, 5.43) | 1.62 (-2.17, 5.55) | 3.41 (-1.19, 8.22) | 1.37 (-2.28, 5.15) | 1.63 (-2.04, 5.42) |
| 1 | -1.08 (-3.22, 1.11) | -0.10 (-2.44, 2.3) | -0.76 (-3.15, 1.69) | 1.13 (-2.34, 4.72) | 1.64 (-2.20, 5.62) | 3.02 (-1.61, 7.87) | 2.05 (-1.63, 5.86) | 1.33 (-2.30, 5.09) |
| 2 | -0.15 (-3.12, 2.91) | 1.11 (-1.75, 4.06) | 0.66 (-2.50, 3.93) | 1.34 (-2.16, 4.96) | 1.73 (-2.14, 5.75) | 4.51 (-0.21, 9.46) | 2.55 (-1.14, 6.38) | 2.05 (-1.55, 5.79) |
| 3 | 1.15 (-0.62, 2.95) | 1.37 (-1.61, 4.43) | 1.81 (-0.82, 4.51) | 1.59 (-1.93, 5.24) | 3.18 (-0.74, 7.25) | 5.21 (0.42, 10.23) | 3.12 (-0.60, 6.97) | 3.29 (-0.41, 7.13) |
| 4 | -0.31 (-1.69, 1.10) | 0.82 (-1.70, 3.4) | -0.10 (-1.97, 1.8) | 1.18 (-2.18, 4.67) | 3.18 (-0.82, 7.35) | 5.26 (0.45, 10.30) | 3.37 (-0.35, 7.23) | 1.85 (-1.87, 5.70) |
| 5 | -1.71 (-4.58, 1.25) | -0.41 (-3.36, 2.64) | -1.34 (-4.36, 1.78) | 2.08 (-1.41, 5.69) | 3.45 (-0.52, 7.58) | 5.58 (0.79, 10.59) | 3.54 (-0.17, 7.39) | 2.37 (-1.33, 6.20) |
| 6 | 2.29 (-0.56, 5.21) | 3.02 (0.36, 5.75) | 3.27 (0.27, 6.37) | 3.42 (-0.03, 6.98) | 5.71 (1.79, 9.77) | 5.84 (1.04, 10.87) | 3.69 (-0.03, 7.55) | 2.47 (-1.20, 6.28) |
| 1-6 | -0.20 (-3.33, 3.04) | 1.57 (-2.07, 5.35) | 0.77 (-2.93, 4.62) | 1.91 (-1.90, 5.88) | 3.91 (-0.53, 8.56) | 5.68 (0.47, 11.16) | 3.40 (-0.49, 7.44) | 2.63 (-1.34, 6.77) |
| 7-12 | 1.09 (-1.59, 3.85) | 2.88 (-0.84, 6.73) | 2.39 (-1.20, 6.12) | 3.42 (-0.32, 7.30) | 4.23 (-0.09, 8.73) | 5.81 (0.71, 11.17) | 4.18 (0.28, 8.23) | 3.67 (-0.33, 7.82) |
| 13-18 | -0.63 (-3.65, 2.48) | -0.90 (-4.65, 3.00) | -0.96 (-4.70, 2.94) | 1.48 (-2.27, 5.37) | 2.83 (-1.61, 7.46) | 4.50 (-0.81, 10.09) | 2.25 (-1.64, 6.30) | 2.92 (-1.09, 7.09) |
| 19-24 | -0.19 (-3.56, 3.29) | -0.76 (-4.48, 3.11) | -0.58 (-4.50, 3.50) | -0.42 (-4.10, 3.40) | -0.25 (-4.50, 4.20) | 0.20 (-4.84, 5.51) | 0.11 (-3.70, 4.06) | 1.01 (-2.93, 5.11) |
| 25-72 | 0.09 (-6.25, 6.86) | -4.75 (-10.21, 1.03) | -3.24 (-9.41, 3.35) | -4.09 (-8.58, 0.62) | -2.11 (-7.53, 3.62) | -4.87 (-10.65, 1.29) | -1.96 (-6.14, 2.40) | -1.99 (-6.42, 2.65) |
| 1-24 | 0.06 (-4.66, 5.02) | 1.18 (-3.71, 6.33) | 0.77 (-4.42, 6.24) | 2.20 (-2.21, 6.81) | 3.74 (-1.53, 9.30) | 5.64 (-0.43, 12.07) | 2.98 (-1.28, 7.42) | 3.16 (-1.30, 7.81) |
| 1-48 | 0.83 (-5.30, 7.35) | 0.83 (-5.07, 7.09) | 0.96 (-5.45, 7.81) | 0.94 (-4.02, 6.15) | 3.31 (-2.67, 9.66) | 3.78 (-2.91, 10.92) | 1.33 (-3.18, 6.04) | 1.68 (-3.09, 6.69) |
| 1-72 | 0.08 (-7.06, 7.78) | -3.48 (-9.75, 3.23) | -2.34 (-9.37, 5.25) | -2.20 (-7.33, 3.20) | 0.47 (-5.80, 7.15) | -1.47 (-8.21, 5.77) | -0.21 (-4.84, 4.64) | -0.06 (-4.98, 5.12) |

Note: A time-stratified case-crossover design with a conditional logistic model was used to derive the estimates while adjusting for natural splines of air temperature and relative humidity at lag 1-72 hours (each with 4 degrees of freedom). Short-term associations were estimated at single-hour lags (lag0-lag6) and for moving averages (lag1-6, lag7-12, lag13-18, lag19-24, lag25-72, lag1-24, lag1-48, and lag1-72). PNC, particle number concentration; PNC₁₀₋₃₀, PNC of particles with 10-30 nm mobility diameter; PNC₃₀₋₁₀₀, PNC of particles with 30-100 nm mobility diameter; PNC₁₀₋₁₀₀, PNC of particles with 10-100 nm mobility diameter; PNC₁₀₀₋₅₀₀, PNC of particles with 100-500 nm mobility diameter; PLC, particle length concentration; PSC, particle surface concentration; PM_{2.5}, particulate matter with an aerodynamic diameter below 2.5 µm; PM₁₀, particulate matter with an aerodynamic diameter below 10 µm. These data correspond to Figure 1.

^a For PSC, measurements during 2005.01.01-2012.04.30 were used.

Table S2. Percent difference (95% CI) in hourly cases of myocardial infarction (MI) per interquartile range increase in particle metrics with additional adjustment for co-pollutants in Augsburg, Germany, from 2005 to 2015.

| Particle | Lag hour | +PNC ₁₀₋₁₀₀ | +PNC ₁₀₀₋₅₀₀ | +PSC | +PM _{2.5} | +PM ₁₀ | +NO ₂ | +O ₃ | +BC |
|------------------------|----------|------------------------|-------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| PNC ₁₀₋₁₀₀ | 4 | / | -0.41 (-2.61, 1.83) | 1.91 (-2.58, 6.61) | -0.49 (-2.64, 1.70) | -0.38 (-2.48, 1.75) | -0.45 (-2.64, 1.78) | -0.15 (-2.08, 1.82) | -0.86 (-3.61, 1.97) |
| | 5 | / | -3.41 (-7.26, 0.60) | -2.85 (-7.95, 2.54) | -2.51 (-5.83, 0.94) | -2.40 (-5.78, 1.11) | -2.72 (-6.33, 1.03) | -1.88 (-5.17, 1.52) | -3.80 (-8.13, 0.73) |
| | 6 | / | 2.30 (-1.19, 5.92) | 2.75 (-2.01, 7.74) | 2.67 (-0.47, 5.90) | 2.90 (-0.29, 6.19) | 3.31 (-0.11, 6.84) | 2.63 (-0.55, 5.91) | 2.47 (-1.59, 6.70) |
| | 1-6 | / | -0.54 (-5.08, 4.22) | 0.84 (-5.67, 7.80) | -0.25 (-4.16, 3.83) | -0.21 (-4.21, 3.96) | 0.15 (-4.28, 4.79) | 0.72 (-3.27, 4.88) | -2.41 (-7.42, 2.88) |
| | 7-12 | / | 0.73 (-3.61, 5.27) | 0.64 (-5.63, 7.32) | 1.67 (-2.08, 5.55) | 1.67 (-2.15, 5.63) | 2.04 (-2.16, 6.43) | 2.02 (-1.86, 6.04) | 0.40 (-4.51, 5.56) |
| | | | | | | | | | |
| PNC ₁₀₀₋₅₀₀ | 4 | 1.44 (-2.19, 5.21) | / | / | / | / | 0.02 (-4.20, 4.42) | 1.14 (-2.65, 5.08) | / |
| | 5 | 4.22 (-0.09, 8.73) | / | / | / | / | 1.19 (-3.28, 5.87) | 1.79 (-2.18, 5.92) | / |
| | 6 | 2.04 (-1.94, 6.18) | / | / | / | / | 3.05 (-1.33, 7.62) | 2.52 (-1.38, 6.57) | / |
| | 1-6 | 2.23 (-2.45, 7.14) | / | / | / | / | 1.66 (-3.57, 7.17) | 2.39 (-2.02, 6.99) | / |
| | 7-12 | 2.99 (-1.48, 7.67) | / | / | / | / | 4.29 (-0.89, 9.73) | 3.14 (-1.21, 7.68) | / |
| | | | | | | | | | |
| PLC | 4 | / | / | / | 1.11 (-3.83, 6.30) | 2.59 (-2.65, 8.12) | 1.64 (-3.63, 7.20) | 2.81 (-1.76, 7.60) | / |
| | 5 | / | / | / | 1.30 (-3.60, 6.45) | 2.41 (-2.76, 7.87) | 1.55 (-3.63, 7.01) | 2.45 (-2.06, 7.16) | / |
| | 6 | / | / | / | 5.61 (0.72, 10.75) | 7.19 (2.02, 12.61) | 5.08 (0.03, 10.38) | 4.25 (-0.15, 8.85) | / |
| | 1-6 | / | / | / | 2.13 (-3.49, 8.07) | 3.18 (-2.80, 9.52) | 2.86 (-3.48, 9.63) | 3.89 (-1.26, 9.30) | / |
| | 7-12 | / | / | / | 3.08 (-2.48, 8.95) | 3.66 (-2.22, 9.88) | 4.10 (-2.13, 10.71) | 3.48 (-1.56, 8.78) | / |
| | | | | | | | | | |
| PSC | 4 | 2.55 (-3.55, 9.04) | / | / | / | / | 4.98 (-1.50, 11.88) | 4.72 (-0.80, 10.55) | / |
| | 5 | 7.06 (0.37, 14.19) | / | / | / | / | 5.36 (-1.09, 12.24) | 5.06 (-0.45, 10.89) | / |
| | 6 | 2.85 (-3.38, 9.48) | / | / | / | / | 6.49 (-0.01, 13.41) | 4.53 (-0.99, 10.35) | / |
| | 1-6 | 2.94 (-4.31, 10.74) | / | / | / | / | 6.23 (-1.38, 14.43) | 5.23 (-0.85, 11.67) | / |
| | 7-12 | 4.98 (-2.20, 12.69) | / | / | / | / | 6.85 (-0.70, 14.98) | 4.59 (-1.39, 10.93) | / |
| | | | | | | | | | |

Note: A time-stratified case-crossover design with a conditional logistic model was used to derive the estimates while adjusting for natural splines of air temperature and relative humidity at lag 1-72 hours (each with 4 degrees of freedom). Short-term hourly associations (lag4, lag5, lag6, lag1-6, and lag7-12) were estimated in two-pollutant models. PNC, particle number concentration; PNC₁₀₋₁₀₀, PNC of particles with 10-100 nm mobility diameter; PNC₁₀₀₋₅₀₀, PNC of particles with 100-500 nm mobility diameter; PLC, particle length concentration; PSC, particle surface concentration; PM_{2.5}, particulate matter with an aerodynamic diameter below 2.5 µm; PM₁₀, particulate matter with an aerodynamic diameter below 10 µm; NO₂, nitrogen dioxide; O₃, ozone; BC, black carbon. In two-pollutant models, we excluded pairs of pollutants that were highly correlated with Spearman correlation coefficients larger than 0.75. These data correspond to the effect estimates in two-pollutant models in Figure 2.

Table S3. Multicollinearity test using generalized variance-inflation factors for main air pollutant (AP) and co-pollutants (CoAP) at different lag hours in the two-pollutant models.

| Particle | Co-pollutant | Lag4 | | Lag5 | | Lag6 | | Lag1-6 | | Lag7-12 | |
|------------------------|-------------------------|------|------|------|------|------|------|--------|------|---------|------|
| | | AP | CoAP | AP | CoAP | AP | CoAP | AP | CoAP | AP | CoAP |
| PNC ₁₀₋₁₀₀ | +PNC ₁₀₀₋₅₀₀ | 1.19 | 1.36 | 1.57 | 1.75 | 1.43 | 1.61 | 1.63 | 1.82 | 1.57 | 1.74 |
| | +PSC | 1.69 | 2.00 | 1.94 | 2.28 | 1.79 | 2.12 | 2.12 | 2.48 | 2.10 | 2.43 |
| | +PM _{2.5} | 1.05 | 1.26 | 1.12 | 1.30 | 1.11 | 1.29 | 1.15 | 1.31 | 1.14 | 1.31 |
| | +PM ₁₀ | 1.07 | 1.23 | 1.17 | 1.31 | 1.15 | 1.29 | 1.20 | 1.33 | 1.19 | 1.33 |
| | +NO ₂ | 1.14 | 1.20 | 1.38 | 1.42 | 1.32 | 1.36 | 1.53 | 1.57 | 1.47 | 1.51 |
| | +O ₃ | 1.06 | 1.19 | 1.19 | 1.30 | 1.17 | 1.28 | 1.24 | 1.35 | 1.25 | 1.37 |
| | +BC | 1.20 | 1.27 | 1.49 | 1.53 | 1.41 | 1.46 | 1.51 | 1.55 | 1.52 | 1.55 |
| PNC ₁₀₀₋₅₀₀ | +PNC ₁₀₋₁₀₀ | 1.36 | 1.19 | 1.75 | 1.57 | 1.61 | 1.43 | 1.82 | 1.63 | 1.74 | 1.57 |
| | +NO ₂ | 1.86 | 1.72 | 1.98 | 1.81 | 1.92 | 1.76 | 2.29 | 2.08 | 2.27 | 2.10 |
| | +O ₃ | 1.48 | 1.44 | 1.53 | 1.48 | 1.52 | 1.48 | 1.59 | 1.54 | 1.63 | 1.61 |
| PLC | +PM _{2.5} | 1.84 | 1.95 | 1.84 | 1.95 | 1.80 | 1.92 | 1.98 | 2.07 | 2.01 | 2.10 |
| | +PM ₁₀ | 2.02 | 2.06 | 2.02 | 2.05 | 1.94 | 1.99 | 2.21 | 2.22 | 2.23 | 2.26 |
| | +NO ₂ | 2.09 | 1.95 | 2.06 | 1.93 | 1.95 | 1.84 | 2.53 | 2.33 | 2.53 | 2.34 |
| | +O ₃ | 1.53 | 1.47 | 1.52 | 1.48 | 1.50 | 1.47 | 1.62 | 1.54 | 1.66 | 1.61 |
| PSC | +PNC ₁₀₋₁₀₀ | 2.00 | 1.69 | 2.28 | 1.94 | 2.12 | 1.79 | 2.48 | 2.10 | 2.43 | 2.10 |
| | +NO ₂ | 2.35 | 20.6 | 2.36 | 2.06 | 2.35 | 2.05 | 2.85 | 2.46 | 2.88 | 2.51 |
| | +O ₃ | 1.71 | 1.51 | 1.72 | 1.52 | 1.73 | 1.54 | 1.83 | 1.59 | 1.85 | 1.65 |

Note: Generalized variance-inflation factors for each main air pollutant and co-pollutant were calculated in the car package based on the method proposed by Fox and Monette (1992). A cutoff value 3 was applied to detect multicollinearity.

Note: PNC, particle number concentration; PNC₁₀₋₁₀₀, PNC of particles with 10-100 nm mobility diameter; PNC₁₀₀₋₅₀₀, PNC of particles with 100-500 nm mobility diameter; PLC, particle length concentration; PSC, particle surface concentration; PM_{2.5}, particulate matter with an aerodynamic diameter below 2.5 µm; PM₁₀, particulate matter with an aerodynamic diameter below 10 µm; NO₂, nitrogen dioxide; O₃, ozone; BC, black carbon. These data correspond to Figure 2.

Table S4. Subgroup analyses of the association of exposure to particle metrics with the onset of myocardial infarction (MI) six hours later in Augsburg, Germany, from 2005 to 2015.

| Characteristic | PNC ₁₀₋₁₀₀ | PNC ₁₀₀₋₅₀₀ | PLC | PSC | PM _{2.5} | PM ₁₀ |
|-------------------------|-----------------------|------------------------|---------------------|----------------------|----------------------|-----------------------|
| Total | 3.27 (0.27, 6.37) | 3.42 (-0.03, 6.98) | 5.71 (1.79, 9.77) | 5.84 (1.04, 10.87) | 3.69 (-0.03, 7.55) | 2.47 (-1.20, 6.28) |
| Male | 5.40 (1.82, 9.09) | 4.84 (0.79, 9.06) | 6.75 (2.19, 11.51) | 7.39 (1.78, 13.30) | 4.75 (0.45, 9.24) | 3.80 (-0.44, 8.22) |
| Female | -2.45 (-8.31, 3.78) | -0.45 (-7.01, 6.58) | 3.04 (-4.44, 11.10) | 1.54 (-7.49, 11.45) | 0.44 (-6.78, 8.22) | -1.67 (-8.84, 6.07) |
| Age (years) | | | | | | |
| 25-59 | 4.56 (-0.24, 9.60) | 3.29 (-2.25, 9.14) | 2.67 (-3.36, 9.08) | 4.98 (-2.44, 12.97) | 2.26 (-3.37, 8.21) | 1.33 (-4.30, 7.29) |
| 60-74 | 2.43 (-1.42, 6.43) | 3.51 (-0.85, 8.07) | 7.69 (2.59, 13.04) | 6.31 (0.13, 12.89) | 4.67 (-0.22, 9.81) | 3.23 (-1.56, 8.24) |
| Admission type | | | | | | |
| Incident | 3.22 (-0.03, 6.57) | 2.87 (-0.91, 6.80) | 5.57 (1.32, 10.00) | 5.35 (0.10, 10.87) | 2.99 (-1.07, 7.22) | 2.16 (-1.87, 6.35) |
| Recurrent | 3.64 (-4.06, 11.97) | 5.91 (-2.35, 14.88) | 6.46 (-3.18, 17.06) | 8.24 (-3.15, 20.95) | 7.18 (-1.83, 17.03) | 4.14 (-4.60, 13.69) |
| Infarction type | | | | | | |
| STEMI | 4.05 (-0.59, 8.91) | 1.60 (-3.74, 7.24) | 4.36 (-1.76, 10.86) | 5.42 (-2.23, 13.68) | 1.73 (-4.13, 7.96) | 2.46 (-3.43, 8.70) |
| NSTEMI | 1.83 (-2.33, 6.17) | 4.78 (0.02, 9.77) | 6.47 (1.15, 12.07) | 6.73 (0.27, 13.61) | 5.50 (0.36, 10.90) | 2.91 (-2.12, 8.19) |
| Living alone | | | | | | |
| Yes | -2.98 (-10.51, 5.17) | 3.65 (-4.83, 12.88) | 7.00 (-2.27, 17.16) | 7.43 (-5.11, 21.62) | 1.06 (-7.67, 10.62) | 0.11 (-8.55, 9.60) |
| No | 5.01 (1.59, 8.56) | 3.60 (-0.34, 7.69) | 5.58 (1.13, 10.23) | 5.28 (-0.03, 10.87) | 3.29 (-0.91, 7.67) | 2.28 (-1.87, 6.61) |
| History of diabetes | | | | | | |
| Yes | 2.16 (-3.15, 7.76) | 1.08 (-5.12, 7.69) | 2.82 (-3.92, 10.04) | 3.00 (-5.22, 11.94) | 0.58 (-5.80, 7.38) | 0.37 (-6.05, 7.23) |
| No | 3.82 (0.19, 7.58) | 4.50 (0.39, 8.78) | 7.11 (2.36, 12.08) | 7.29 (1.45, 13.47) | 5.14 (0.60, 9.87) | 3.46 (-0.98, 8.09) |
| History of hypertension | | | | | | |
| Yes | 3.62 (0.29, 7.05) | 4.42 (0.54, 8.44) | 7.06 (2.55, 11.76) | 6.16 (0.78, 11.82) | 4.86 (0.62, 9.29) | 3.27 (-0.91, 7.64) |
| No | 1.66 (-5.22, 9.04) | -0.33 (-7.65, 7.56) | 1.25 (-6.46, 9.60) | 4.50 (-5.76, 15.88) | -0.38 (-7.92, 7.77) | -0.22 (-7.70, 7.86) |
| Education level | | | | | | |
| Low | 3.17 (-0.74, 7.23) | 2.17 (-2.26, 6.80) | 5.02 (-0.05, 10.35) | 5.76 (-0.39, 12.30) | 2.41 (-2.44, 7.50) | 1.97 (-2.82, 7.00) |
| Medium | 5.11 (-1.93, 12.65) | 5.72 (-2.94, 15.16) | 4.44 (-4.60, 14.33) | 0.90 (-10.33, 13.52) | 3.32 (-5.17, 12.56) | 2.16 (-6.3, 11.40) |
| High | 6.56 (-3.10, 17.17) | 6.86 (-4.14, 19.11) | 7.05 (-4.76, 20.33) | 4.17 (-9.97, 20.52) | 0.50 (-10.62, 12.99) | -0.12 (-11.08, 12.19) |
| Obesity | | | | | | |
| Yes | 2.94 (-2.93, 9.15) | 1.96 (-4.4, 8.75) | 2.08 (-5.23, 9.95) | 7.35 (-1.77, 17.31) | 0.07 (-6.80, 7.46) | -0.87 (-7.51, 6.24) |
| No | 3.77 (0.15, 7.52) | 4.46 (0.23, 8.88) | 7.29 (2.52, 12.28) | 5.46 (-0.35, 11.62) | 4.30 (-0.26, 9.07) | 3.16 (-1.38, 7.91) |
| Smoking status | | | | | | |
| Smoker | 4.25 (-0.47, 9.20) | 1.38 (-4.10, 7.17) | 5.70 (-0.58, 12.37) | 6.69 (-1.21, 15.22) | 1.77 (-4.18, 8.09) | 2.46 (-3.56, 8.84) |
| Ex-smoker | 5.26 (-0.15, 10.96) | 7.70 (1.34, 14.46) | 7.50 (0.30, 15.22) | 6.77 (-1.94, 16.25) | 5.76 (-1.02, 13.01) | 3.52 (-2.93, 10.39) |
| Nonsmoker | 0.66 (-5.59, 7.33) | 2.73 (-3.94, 9.88) | 3.55 (-3.74, 11.39) | 3.42 (-5.34, 13.00) | 3.20 (-3.87, 10.80) | 1.20 (-5.89, 8.82) |

Note: The estimates of the association are percentage increase (95% CI) in hourly cases of MI per interquartile range increase in particle metrics at lag 6 hour. A time-stratified case-crossover design with a conditional logistic model was used to estimate the association while adjusting for natural splines of air temperature and relative humidity at lag 1-72 hours (each with 4 degrees of freedom). Stratified analyses were conducted for each subgroup.

STEMI, ST segment elevation MI; NSTEMI, non-ST segment elevation MI; PNC, particle number concentration; PNC₁₀₋₁₀₀, PNC of particles with 10-100 nm mobility diameter; PNC₁₀₀₋₅₀₀, PNC of particles with 100-500 nm mobility diameter; PLC, particle length concentration; PSC, particle surface concentration; PM_{2.5}, particulate matter with an aerodynamic diameter below 2.5 µm; PM₁₀, particulate matter with an aerodynamic diameter below 10 µm. For PSC, measurements during 2005.01.01-2012.04.30 were used.

Table S5. Sensitivity analyses of the association between exposure to particle metrics and the onset of myocardial infarction (MI) six hours later in Augsburg, Germany from 2005 to 2015.

| | PNC ₁₀₋₁₀₀ | PNC ₁₀₀₋₅₀₀ | PLC | PSC | PM _{2.5} | PM ₁₀ |
|--|-----------------------|------------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Main model (<i>n</i> = 5898) | 3.27 (0.27, 6.37) | 3.42 (-0.03, 6.98) | 5.71 (1.79, 9.77) | 5.84 (1.04, 10.87) | 3.69 (-0.03, 7.55) | 2.47 (-1.20, 6.28) |
| Including 1377 patients aged 75-84 years in 2009-2015 (<i>n</i> = 7275) | 3.14 (0.40, 5.96) | 2.10 (-0.93, 5.22) | 5.28 (1.75, 8.93) | 5.81 (1.38, 10.43) | 3.16 (-0.22, 6.65) | 2.30 (-1.06, 5.77) |
| Temperature at lag period 1-120 hours (5 days) (<i>n</i> = 5898) | 3.16 (0.17, 6.25) | 3.20 (-0.21, 6.72) | 5.35 (1.49, 9.36) | 5.38 (0.69, 10.29) | 3.48 (-0.19, 7.29) | 2.30 (-1.34, 6.07) |
| Current and lagged (1-24 hours) temperature (<i>n</i> = 5898) | 3.13 (0.09, 6.26) | 3.41 (-0.09, 7.03) | 5.64 (1.69, 9.74) | 5.39 (0.57, 10.44) | 3.81 (0.11, 7.65) | 2.49 (-1.2, 6.31) |
| Current and lagged (1-48 hours) temperature (<i>n</i> = 5898) | 3.00 (-0.03, 6.13) | 3.09 (-0.41, 6.72) | 5.32 (1.36, 9.43) | 5.36 (0.51, 10.44) | 3.54 (-0.20, 7.41) | 2.17 (-1.54, 6.01) |
| Current and lagged (1-72 hours) temperature (<i>n</i> = 5898) | 3.00 (-0.03, 6.13) | 2.91 (-0.60, 6.54) | 5.15 (1.20, 9.27) | 5.25 (0.41, 10.32) | 3.29 (-0.44, 7.17) | 1.93 (-1.77, 5.77) |
| Concurrent (6 hours, same as particle metrics) and lagged (25-72 hours) temperature (<i>n</i> = 5898) | 3.49 (0.43, 6.64) | 3.85 (0.30, 7.52) | 6.04 (2.04, 10.20) | 5.44 (0.49, 10.64) | 3.92 (0.17, 7.81) | 2.60 (-1.11, 6.45) |
| Fixed time strata using 3 weeks (<i>n</i> = 5898) | 2.79 (-0.39, 6.07) | 2.52 (-1.08, 6.24) | 5.37 (1.13, 9.80) | 3.87 (-1.08, 9.08) | 3.47 (-0.60, 7.71) | 2.63 (-1.43, 6.86) |

Note: Associations are presented as percentage increase (95% CI) in hourly cases of MI per interquartile range increase in particle metrics. PNC, particle number concentration; PNC₁₀₋₁₀₀, PNC of particles with 10-100 nm mobility diameter; PNC₁₀₀₋₅₀₀, PNC of particles with 100-500 nm mobility diameter; PLC, particle length concentration; PSC, particle surface concentration; PM_{2.5}, particulate matter with an aerodynamic diameter below 2.5 µm; PM₁₀, particulate matter with an aerodynamic diameter below 10 µm.

Table S6. Ratio and Spearman correlation coefficient (r) between particle number concentration measurements at different types of ULTRA3 monitoring stations and the main monitoring station (Main) in Augsburg from March 6, 2014 to April 7, 2015.

| Type of stations | N of stations | N of hours | Ratio (ULTRA3/Main) | Correlation r (ULTRA3-Main) |
|---------------------|---------------|------------|------------------------|--------------------------------|
| Regional background | 4 | 3,092 | 0.82 | 0.61 |
| Regional traffic | 4 | 3,287 | 1.02 | 0.63 |
| Urban background | 5 | 3,177 | 0.92 | 0.80 |
| Urban traffic | 6 | 2,734 | 1.37 | 0.75 |
| Industry area | 1 | 1,000 | 1.39 | 0.77 |

Note: Since only a maximum of four ULTRA3 stations were operated simultaneously, for each hour, the corresponding measurement in one station or the average of multiple stations in each type was used to represent the hourly measurement of each type of station.

Figure S1. Particle size ranges and contributions to number concentration within a size range of 10-800 nm in the mobility diameter (Augsburg, Germany, from 2005 to 2015).

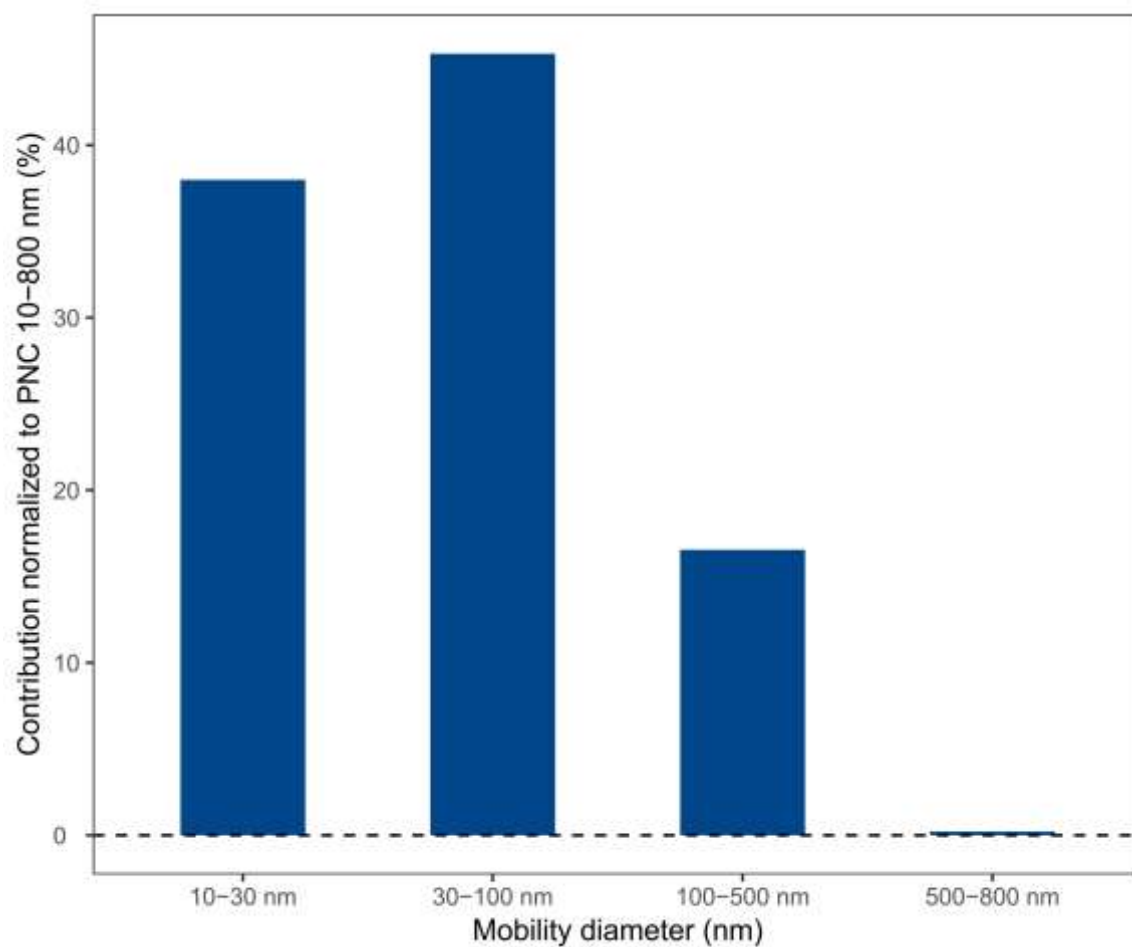
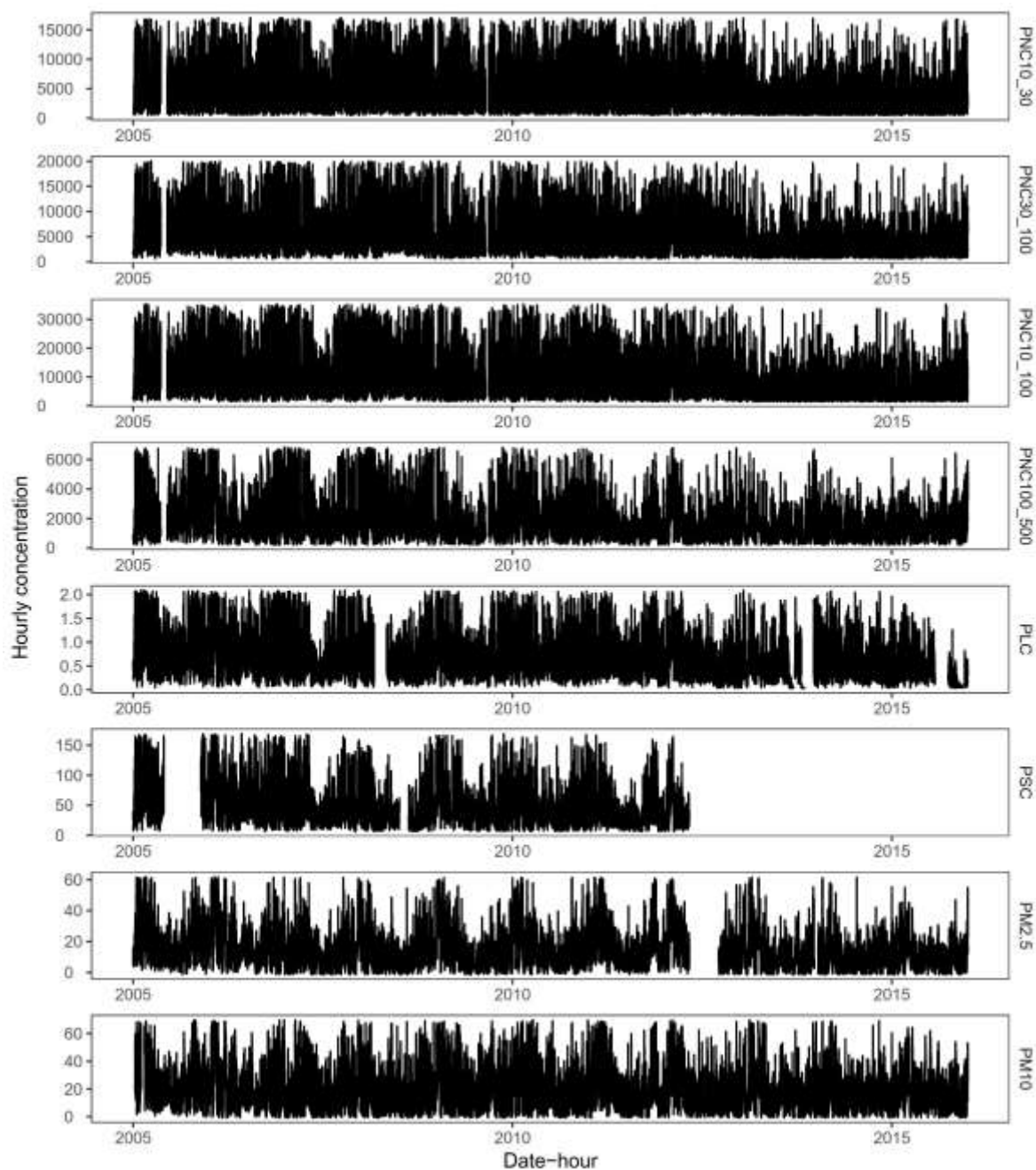


Figure S2. Time-series of hourly particle metrics in Augsburg, Germany, from 2005 to 2015.



Note: PNC, particle number concentration; PNC_{10-30} , PNC of particles with 10-30 nm mobility diameter; PNC_{30-100} , PNC of particles with 30-100 nm mobility diameter; PNC_{10-100} , PNC of particles with 10-100 nm mobility diameter; $PNC_{100-500}$, PNC of particles with 100-500 nm mobility diameter; PLC, particle length concentration; PSC, particle surface concentration; $PM_{2.5}$, particulate matter with an aerodynamic diameter below 2.5 μm ; PM_{10} , particulate matter with an aerodynamic diameter below 10 μm . For PSC, measurements during 2005.01.01-2012.04.30 were used.

Figure S3. Location of the main and 20 sampling monitoring sites in the Augsburg region between March 2014 and April 2015.

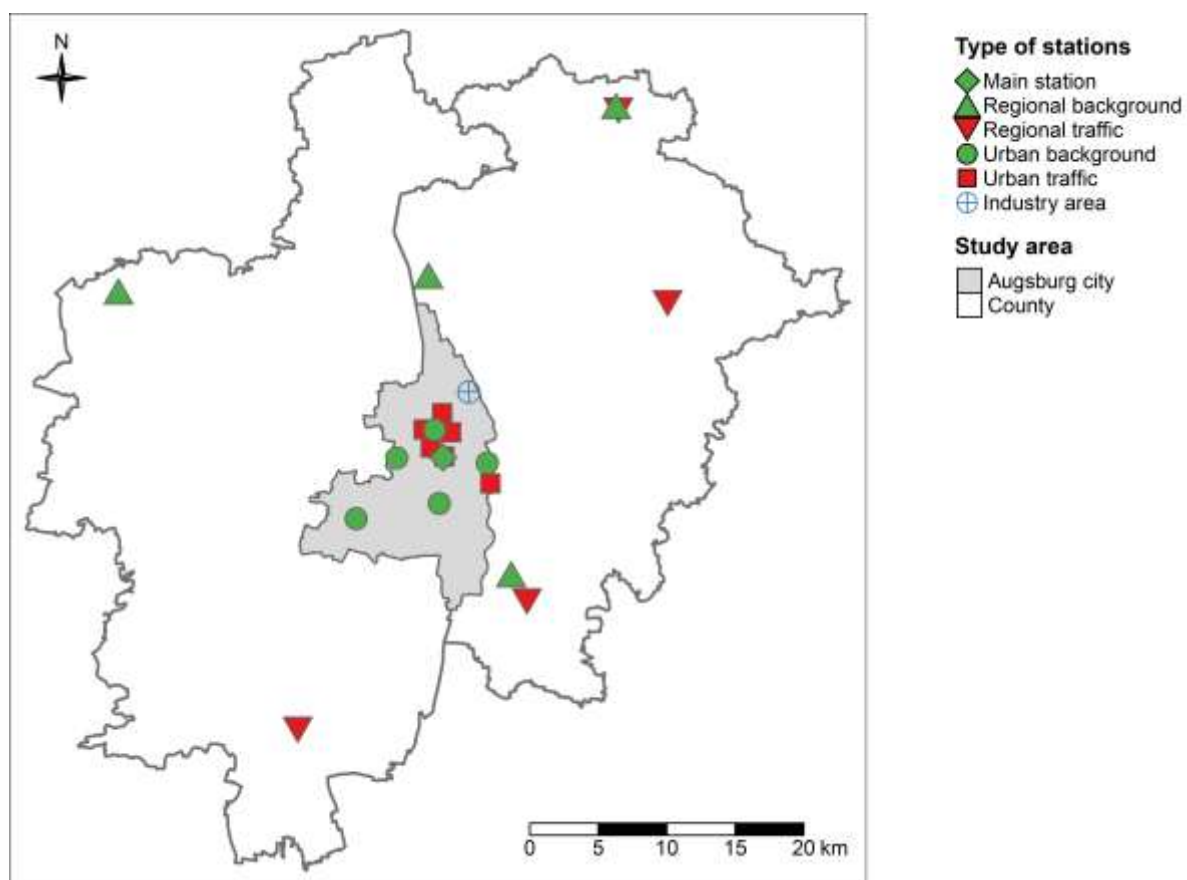
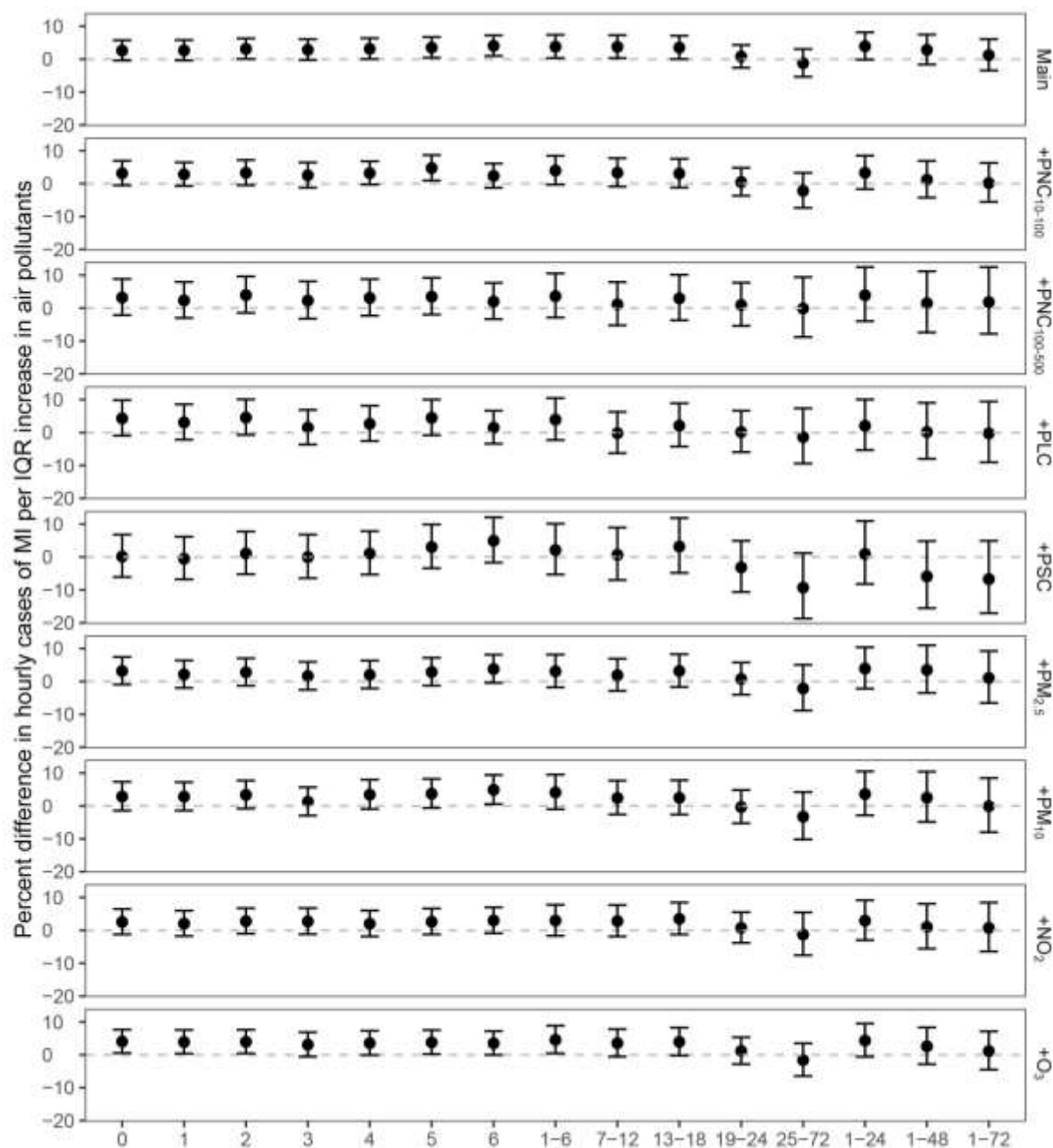
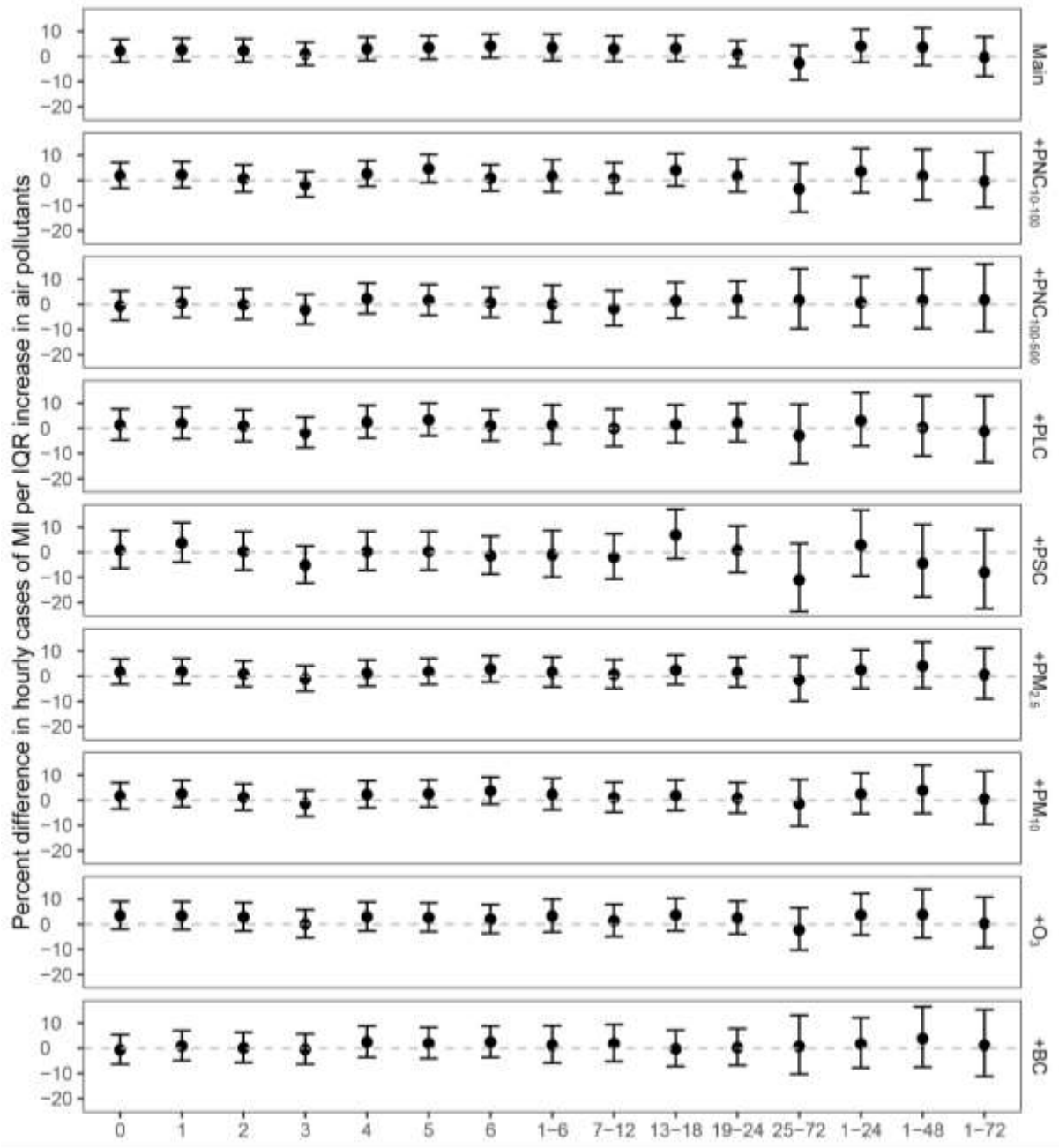


Figure S4. Percent difference (95% CI) in hourly cases of myocardial infarction (MI) per interquartile range increase in black carbon (BC) at different lag hours with and without adjustment for co-pollutants in Augsburg, Germany from 2005 to 2015.



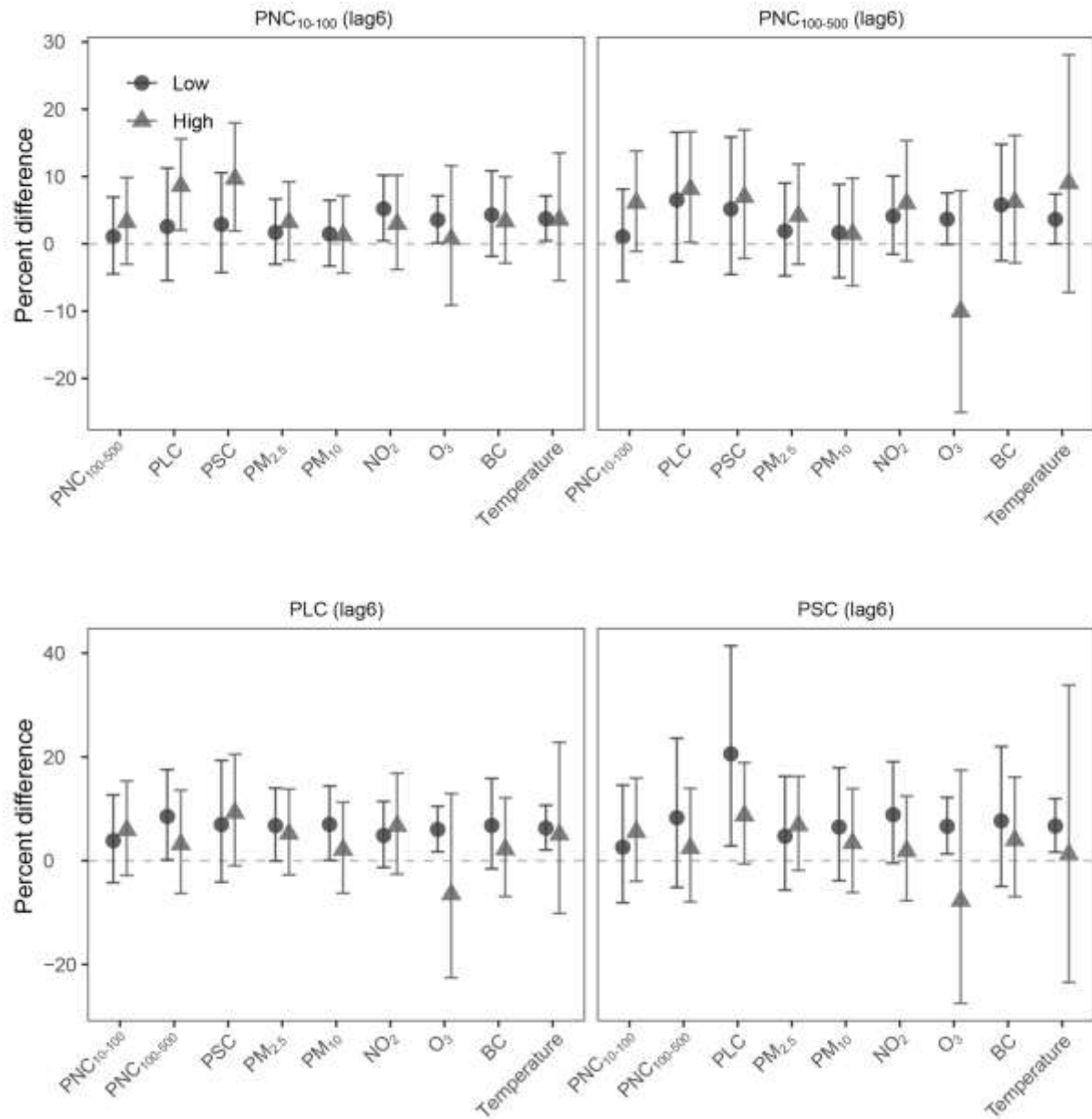
Note: A time-stratified case-crossover design with a conditional logistic model was used to derive the estimates while adjusting for natural splines of air temperature and relative humidity at lag 1-72 hours (each with 4 degrees of freedom). Short-term associations were estimated at single-hour lags (lag0-lag6) and for moving averages (lag1-6, lag7-12, lag13-18, lag19-24, lag25-72, lag1-24, lag1-48, and lag1-72). PNC, particle number concentration; PNC₁₀₋₃₀, PNC of particles with 10-30 nm mobility diameter; PNC₃₀₋₁₀₀, PNC of particles with 30-100 nm mobility diameter; PNC₁₀₋₁₀₀, PNC of particles with 10-100 nm mobility diameter; PNC₁₀₀₋₅₀₀, PNC of particles with 100-500 nm mobility diameter; PLC, particle length concentration; PSC, particle surface concentration; PM_{2.5}, particulate matter with an aerodynamic diameter below 2.5 μm ; PM₁₀, particulate matter with an aerodynamic diameter below 10 μm ; NO₂, nitrogen dioxide; and O₃, ozone. For PSC, measurements during 2005.01.01-2012.04.30 were used.

Figure S5. Percent difference (95% CI) in hourly cases of myocardial infarction (MI) per interquartile range increase in nitrogen dioxide (NO_2) at different lag hours with and without adjustment for co-pollutants in Augsburg, Germany from 2005 to 2015.



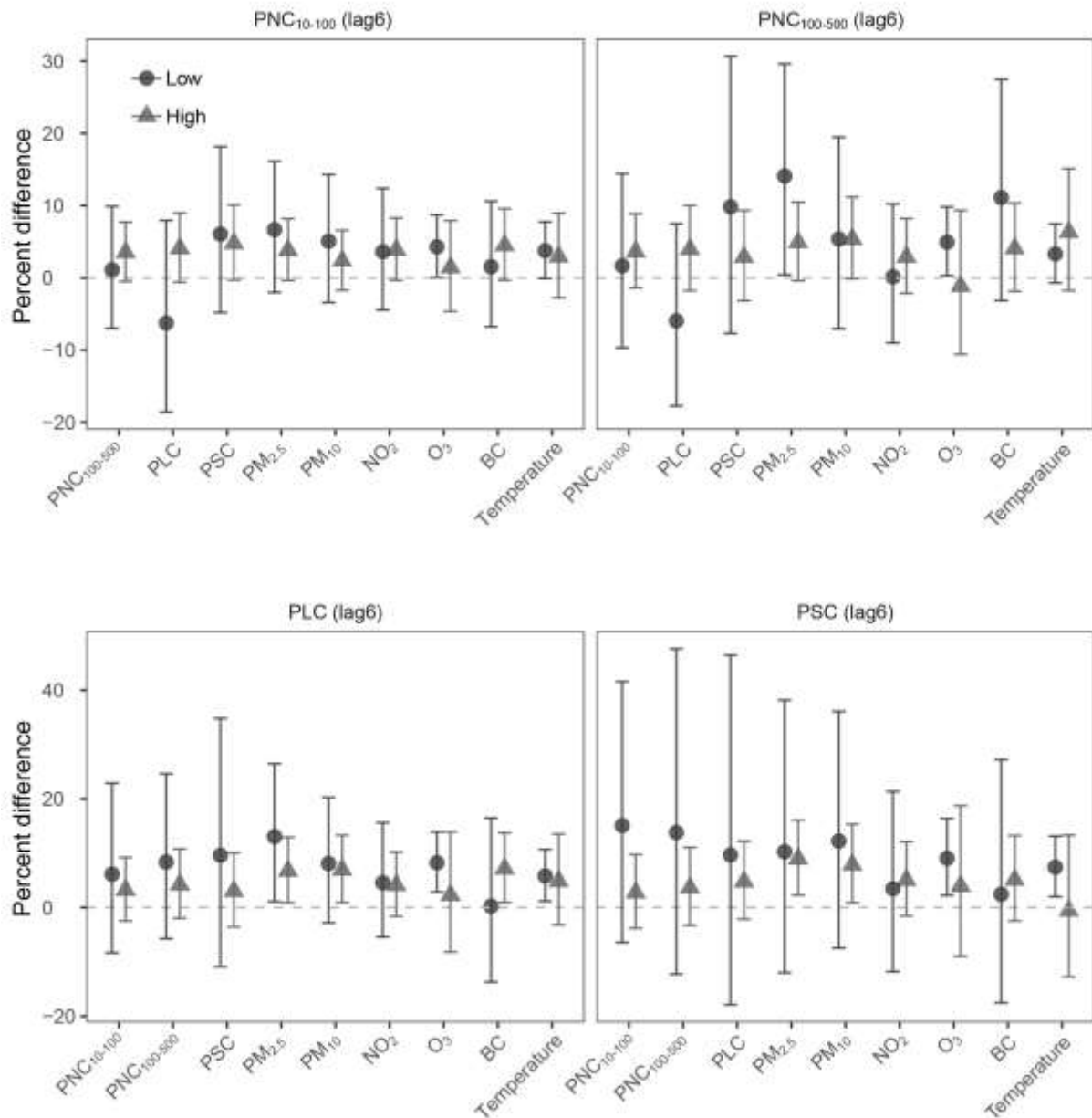
Note: A time-stratified case-crossover design with a conditional logistic model was used to derive the estimates while adjusting for natural splines of air temperature and relative humidity at lag 1-72 hours (each with 4 degrees of freedom). Short-term associations were estimated at single-hour lags (lag0-lag6) and for moving averages (lag1-6, lag7-12, lag13-18, lag19-24, lag25-72, lag1-24, lag1-48, and lag1-72). PNC, particle number concentration; PNC₁₀₋₃₀, PNC of particles with 10-30 nm mobility diameter; PNC₃₀₋₁₀₀, PNC of particles with 30-100 nm mobility diameter; PNC₁₀₋₁₀₀, PNC of particles with 10-100 nm mobility diameter; PNC₁₀₀₋₅₀₀, PNC of particles with 100-500 nm mobility diameter; PLC, particle length concentration; PSC, particle surface concentration; PM_{2.5}, particulate matter with an aerodynamic diameter below 2.5 μm ; PM₁₀, particulate matter with an aerodynamic diameter below 10 μm ; O₃, ozone; and BC, black carbon. For PSC, measurements during 2005.01.01-2012.04.30 were used.

Figure S6. Effect modification by high ($> 75^{\text{th}}$ percentile) and low ($\leq 75^{\text{th}}$ percentile) levels of co-pollutants and air temperature for the association of exposure to particle metrics with the onset of myocardial infarction (MI) six hours later in Augsburg, Germany from 2005 to 2015.



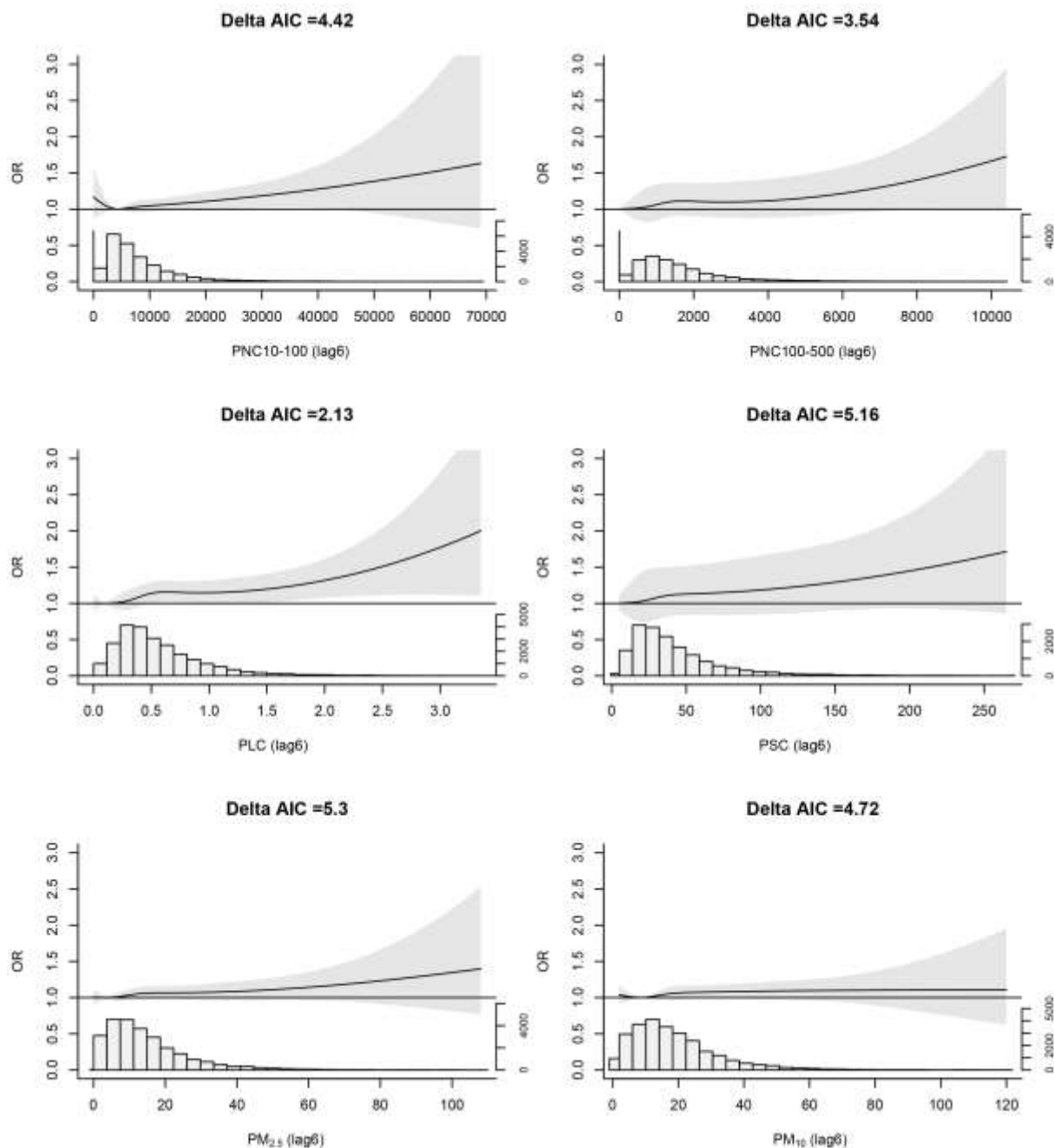
Note: A time-stratified case-crossover design with a conditional logistic model was used to derive the estimates while adjusting for natural splines of air temperature and relative humidity at lag 1-72 hours (each with 4 degrees of freedom). PNC, particle number concentration; PNC₁₀₋₁₀₀, PNC of particles with 10-100 nm morbidity diameter; PNC₁₀₀₋₅₀₀, PNC of particles with 100-500 nm morbidity diameter; PLC, particle length concentration; PSC, particle surface concentration; PM_{2.5}, particulate matter with an aerodynamic diameter below 2.5 μm ; PM₁₀, particulate matter with an aerodynamic diameter below 10 μm ; NO₂, nitrogen dioxide; O₃, ozone; and BC, black carbon. For PSC, measurements during 2005.01.01-2012.04.30 were used.

Figure S7. Effect modification by high ($> 50^{\text{th}}$ percentile) and low ($\leq 50^{\text{th}}$ percentile) levels of co-pollutants and air temperature for the association of exposure to particle number (PNC), length (PLC), and surface area (PSC) concentrations with the onset of myocardial infarction (MI) six hours later in Augsburg, Germany, from 2005 to 2015.



Note: A time-stratified case-crossover design with a conditional logistic model was used to derive the estimates while adjusting for natural splines of air temperature and relative humidity at lag 1-72 hours (each with 4 degrees of freedom). PNC, particle number concentration; PNC₁₀₋₁₀₀, PNC of particles with 10-100 nm morbidity diameter; PNC₁₀₀₋₅₀₀, PNC of particles with 100-500 nm morbidity diameter; PLC, particle length concentration; PSC, particle surface concentration; PM_{2.5}, particulate matter with an aerodynamic diameter below 2.5 μm ; PM₁₀, particulate matter with an aerodynamic diameter below 10 μm ; NO₂, nitrogen dioxide; O₃, ozone; and BC, black carbon. For PSC, measurements during 2005.01.01-2012.04.30 were used.

Figure S8. Exposure-response curves (solid lines) and 95% confidence intervals (grey-shaded area) for the association between particle metrics and the onset of myocardial infarction six hours later, with related particle metrics distributions (histogram) in Augsburg, Germany, from 2005 to 2015. A natural cubic spline with 4 degrees of freedom for air pollutant was included in a conditional logistic model to derive the exposure-response curves while adjusting for natural splines of air temperature and relative humidity at lag 1-72 hours (each with 4 degrees of freedom).



Note: Delta AIC denotes the Akaike Information Criterion (AIC) of the nonlinear model for air pollutant minus that of a linear model for air pollutant. Delta AIC > 0 means that the nonlinear model does not have better model fit. Reference values of the exposure-response curves were selected based on the air pollution concentration that yielded the minimum risk on myocardial infarction events.