Environ Health Perspect

DOI: 10.1289/EHP2054

Note to readers with disabilities: *EHP* strives to ensure that all journal content is accessible to all readers. However, some figures and Supplemental Material published in *EHP* articles may not conform to 508 standards due to the complexity of the information being presented. If you need assistance accessing journal content, please contact ehp508@niehs.nih.gov. Our staff will work with you to assess and meet your accessibility needs within 3 working days.

Supplemental Material

Ultrafine and Fine Particle Number and Surface Area Concentrations and Daily Cause-Specific Mortality in the Ruhr Area, Germany, 2009–2014

Frauke Hennig, Ulrich Quass, Bryan Hellack, Miriam Küpper, Thomas A. J. Kuhlbusch, Massimo Stafoggia, and Barbara Hoffmann

Table of Contents

Table S1. Estimated %-differences in daily natural and cause-specific mortality per IQR of air pollutant concentration for particle metrics ($PNC_{\leq 100}$, $PNC_{100\text{-}750}$, PSC, and PM_{10}) at single day lags (0-7) and aggregated lags (0-1, 2-3, 4-7) in the Ruhr area between March 2009 and December 2014, using Poisson regression models, adjusted for time trend, temperature, humidity, day of week, holidays, period of seasonal population decrease and influenza. (Corresponding results are visualized in Figure 2.)

Table S2. Estimated %-differences in daily natural and cause-specific mortality per IQR increase in size-specific particle number concentrations ($PNC_{13.3\text{-}30}$, $PNC_{30\text{-}50}$, $PNC_{50\text{-}100}$, $PNC_{100\text{-}250}$, $PNC_{100\text{-}250}$, $PNC_{250\text{-}500}$, $PNC_{500\text{-}750}$) at aggregated (lags 0-1, 2-3, and 4-7) in the Ruhr area between March 2009 and December 2014, using Poisson regression models, adjusted for time trend, temperature, humidity, day of week, holidays, period of seasonal population decrease and influenza. (Corresponding results are visualized in Figure 3.)

Figure S1. Effect Estimates for %-differences (95%-CI) in Natural-and Cardiovascular-specific mortality in the Ruhr area between March 2009 and December 2014 per IQR increase in ultrafine particles ($PNC_{13.3\text{-}30}$), estimated in Poisson regression models, adjusted for time trend, temperature, humidity, day of week, holidays, period of seasonal population decrease and influenza with additional adjustment for PM_{10}, NO_2, O_3, $PNC_{>100}$, and PSC.

Table S3. Estimated %-differences in daily natural and cause-specific mortality per IQR increase in particle number concentrations ($PNC_{<100}$ and $PNC_{100\text{-}750}$) at aggregated (lags 0-1, 2-3, and 4-7) in the Ruhr area between March 2009 and December 2014 considering effect modification presented at group-specific exposure effect estimate [95%-CI] (p-value of the interaction term). (Corresponding results are visualized Figure 5).

Table S1: Estimated %-differences in daily natural and cause-specific mortality per IQR of air pollutant concentration for particle metrics ($PNC_{\leq 100}$, $PNC_{100\text{-}750}$, PSC, and PM_{10}) at single day lags (0-7) and aggregated lags (0-1, 2-3, 4-7) in the Ruhr area between March 2009 and December 2014, using Poisson regression models, adjusted for time trend, temperature, humidity, day of week, holidays, period of seasonal population decrease and influenza. (Corresponding results are visualized in Figure 2.)

Outcome	Lag	$PNC_{\leq 100}$ IQR=4900.2	$PNC_{100\text{-}750}$ IQR=1060.9	PSC IQR=21.7	PM_{10} IQR=13.3
Natural Mortality	lag0	-0.49 (-1.75, 0.79)	0.99 (-0.05, 2.05)	0.60 (-0.52, 1.73)	0.37 (-0.47, 1.22)
	lag1	-0.59 (-1.83, 0.67)	0.72 (-0.32, 1.77)	0.69 (-0.43, 1.82)	0.60 (-0.22, 1.43)
	lag2	-0.02 (-1.27, 1.24)	-0.17 (-1.22, 0.89)	0.16 (-0.95, 1.29)	0.12 (-0.70, 0.95)
	lag3	-1.00 (-2.24, 0.24)	0.26 (-0.76, 1.29)	0.22 (-0.87, 1.33)	0.37 (-0.45, 1.20)
	lag4	-0.07 (-1.28, 1.15)	0.98 (0.00, 1.98)	0.85 (-0.19, 1.91)	0.53 (-0.27, 1.34)
	lag5	0.75 (-0.46, 1.98)	0.91 (-0.05, 1.89)	0.79 (-0.25, 1.85)	0.24 (-0.56, 1.05)
	lag6	0.43 (-0.76, 1.64)	0.92 (-0.04, 1.90)	1.14 (0.11, 2.17)	0.74 (-0.04, 1.54)
	lag7	-0.28 (-1.46, 0.92)	0.35 (-0.61, 1.32)	0.51 (-0.51, 1.54)	0.53 (-0.25, 1.32)
	lag0-1	-0.78 (-2.36, 0.83)	1.12 (-0.09, 2.33)	0.84 (-0.45, 2.16)	0.67 (-0.29, 1.64)
	lag2-3	-0.75 (-2.29, 0.82)	0.06 (-1.13, 1.26)	0.23 (-1.06, 1.54)	0.27 (-0.67, 1.22)
	lag4-7	0.44 (-1.51, 2.43)	1.56 (0.22, 2.92)	1.56 (0.12, 3.03)	0.97 (-0.13, 2.09)
Cardiovascular Mortality	lag0	-0.58 (-2.72, 1.61)	1.41 (-0.36, 3.21)	0.64 (-1.25, 2.57)	0.52 (-0.91, 1.97)
	lag1	-0.77 (-2.85, 1.36)	0.98 (-0.78, 2.78)	0.82 (-1.06, 2.74)	1.02 (-0.40, 2.45)
	lag2	-0.07 (-2.18, 2.09)	-0.68 (-2.43, 1.11)	-0.33 (-2.21, 1.58)	-0.02 (-1.42, 1.40)
	lag3	0.72 (-1.41, 2.90)	0.47 (-1.27, 2.24)	0.61 (-1.22, 2.48)	0.24 (-1.14, 1.64)
	lag4	1.13 (-0.97, 3.27)	0.63 (-1.05, 2.34)	0.54 (-1.24, 2.35)	-0.11 (-1.47, 1.27)
	lag5	0.90 (-1.15, 3.00)	0.35 (-1.31, 2.04)	0.54 (-1.20, 2.31)	-0.25 (-1.59, 1.11)
	lag6	0.42 (-1.62, 2.51)	0.62 (-1.02, 2.29)	1.36 (-0.39, 3.14)	0.80 (-0.53, 2.16)
	lag7	0.37 (-1.67, 2.46)	0.20 (-1.44, 1.86)	0.69 (-1.03, 2.44)	1.04 (-0.30, 2.39)
	lag0-1	-0.72 (-3.37, 2.00)	1.63 (-0.40, 3.71)	0.94 (-1.25, 3.18)	0.99 (-0.63, 2.65)
	lag2-3	0.33 (-2.33, 3.06)	-0.30 (-2.31, 1.75)	0.00 (-2.17, 2.22)	0.04 (-1.55, 1.66)
	lag4-7	2.01 (-1.41, 5.55)	0.89 (-1.43, 3.27)	1.61 (-0.87, 4.15)	0.75 (-1.13, 2.67)
Respiratory Mortality	lag0	0.27 (-3.96, 4.69)	0.04 (-3.37, 3.57)	-0.21 (-3.82, 3.54)	-0.82 (-3.52, 1.96)
	lag1	0.07 (-4.10, 4.42)	0.19 (-3.26, 3.77)	0.90 (-2.73, 4.67)	0.56 (-2.10, 3.30)
	lag2	3.50 (-0.77, 7.95)	-1.60 (-5.05, 1.98)	-1.17 (-4.80, 2.60)	-1.08 (-3.76, 1.67)
	lag3	-2.76 (-6.83, 1.48)	-2.64 (-6.00, 0.83)	-3.47 (-6.98, 0.17)	-1.76 (-4.40, 0.95)
	lag4	-2.28 (-6.32, 1.92)	0.57 (-2.69, 3.94)	-0.35 (-3.78, 3.21)	0.97 (-1.64, 3.66)
	lag5	-1.48 (-5.47, 2.68)	0.22 (-2.99, 3.53)	-0.07 (-3.46, 3.44)	0.21 (-2.39, 2.88)
	lag6	4.51 (0.37, 8.81)	2.06 (-1.17, 5.39)	2.08 (-1.34, 5.62)	0.25 (-2.35, 2.92)
	lag7	-0.21 (-4.23, 3.98)	1.40 (-1.85, 4.75)	0.74 (-2.65, 4.26)	0.61 (-1.96, 3.25)
	lag0-1	0.04 (-5.17, 5.54)	0.02 (-3.84, 4.04)	0.39 (-3.73, 4.69)	-0.11 (-3.12, 2.99)
	lag2-3	1.20 (-4.06, 6.74)	-2.53 (-6.42, 1.53)	-3.00 (-7.10, 1.27)	-2.17 (-5.17, 0.93)
	lag4-7	-0.68 (-7.06, 6.15)	1.67 (-2.73, 6.28)	1.23 (-3.58, 6.27)	1.10-2.45, 4.77)

Table S2: Estimated %-differences in daily natural and cause-specific mortality per IQR increase in size-specific particle number concentrations ($PNC_{13.3-30}$, PNC_{30-50}, PNC_{50-100}, $PNC_{100-250}$, $PNC_{100-250}$, $PNC_{250-500}$, $PNC_{500-750}$) at aggregated (lags 0-1, 2-3, and 4-7) in the Ruhr area between March 2009 and December 2014, using Poisson regression models, adjusted for time trend, temperature, humidity, day of week, holidays, period of seasonal population decrease and influenza. (Corresponding results are visualized in Figure 3.)

Outcome	Lag	$PNC_{13.3-30}$ IQR=2438.2	PNC_{30-50} IQR=1492.5	PNC_{50-100} IQR=1608.7	$PNC_{100-250}$ IQR=903.2	$PNC_{250-500}$ IQR=180.8	$PNC_{500-750}$ IQR=14.0
Natural Mortality	lag0-1	-1.81 (-3.30, -0.30)	-0.60 (-2.24, 1.07)	1.03 (-0.45, 2.52)	1.11 (-0.10, 2.32)	0.85 (-0.33, 2.05)	0.28 (-0.60, 1.17)
	lag2-3	-1.20 (-2.66, 0.28)	-0.16 (-1.79, 1.50)	-0.09 (-1.57, 1.41)	-0.02 (-1.21, 1.18)	0.40 (-0.75, 1.57)	0.28 (-0.58, 1.15)
	lag4-7	-0.55 (-2.40, 1.34)	0.56 (-1.54, 2.71)	1.46 (-0.31, 3.27)	1.52 (0.18, 2.88)	1.49 (0.15, 2.85)	0.75 (-0.27, 1.78)
Cardiovascular Mortality	lag0-1	-1.63 (-4.16, 0.97)	-0.86 (-3.62, 1.98)	1.06 (-1.43, 3.60)	1.52 (-0.51, 3.59)	1.71 (-0.28, 3.75)	1.01 (-0.49, 2.52)
	lag2-3	-0.08 (-2.59, 2.50)	1.05 (-1.75, 3.92)	0.22 (-2.28, 2.79)	-0.28 (-2.29, 1.77)	-0.36 (-2.31, 1.63)	0.18 (-1.28, 1.66)
	lag4-7	1.43 (-1.86, 4.83)	2.06 (-1.63, 5.89)	1.75 (-1.32, 4.90)	0.84 (-1.48, 3.22)	0.96 (-1.34, 3.33)	0.75 (-1.03, 2.57)
Respiratory Mortality	lag0-1	-0.28 (-5.25, 4.95)	-0.68 (-6.06, 5.01)	0.99 (-3.83, 6.07)	0.36 (-3.50, 4.37)	-1.45 (-5.24, 2.49)	-1.51 (-4.36, 1.43)
	lag2-3	2.59 (-2.41, 7.85)	1.50 (-3.98, 7.29)	-1.89 (-6.71, 3.18)	-2.52 (-6.39, 1.52)	-1.88 (-5.65, 2.04)	-1.06 (-3.87, 1.83)
	lag4-7	-3.05 (-9.05, 3.34)	1.14 (-5.83, 8.62)	1.71 (-4.13, 7.92)	1.40 (-3.01, 6.01)	2.62 (-1.73, 7.17)	1.42 (-1.88, 4.84)

Figure S1: Effect Estimates for %-differences (95%-CI) in Natural-and Cardiovascular-specific mortality in the Ruhr area between March 2009 and December 2014 per IQR increase in ultrafine particles ($PNC_{13.3-30}$), estimated in Poisson regression models, adjusted for time trend, temperature, humidity, day of week, holidays, period of seasonal population decrease and influenza with additional adjustment for PM_{10}, NO_2, O_3, $PNC_{>100}$, and PSC.

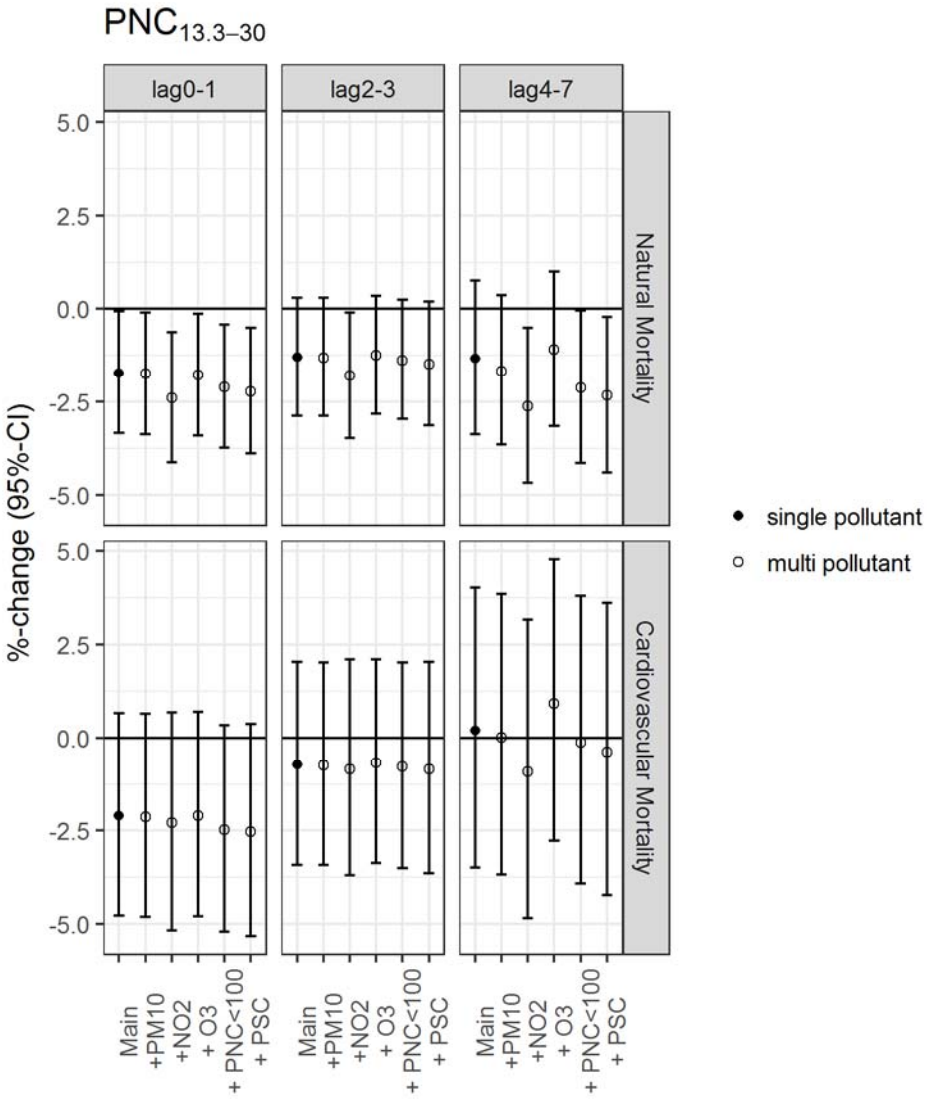

Table S3: Estimated %-differences in daily natural and cause-specific mortality per IQR increase in particle number concentrations ($PNC_{<100}$ and $PNC_{100-750}$) at aggregated (lags 0-1, 2-3, and 4-7) in the Ruhr area between March 2009 and December 2014 considering effect modification presented at group-specific exposure effect estimate [95%-CI] (p-value of the interaction term). (Corresponding results are visualized Figure 5).

Effect Modifier	Natural Mortality		Cardiovascular Mortality	
	$PNC_{<100}$	$PNC_{100-750}$	$PNC_{<100}$	$PNC_{100-750}$
		Lag0-1		
Season				
Oct-Mar	-0.25 [-2.30; 1.84] (p=0.53)	1.46 [-0.08; 3.02] (p=0.67)	-1.04 [-4.49; 2.53] (p=1.00)	1.37 [-1.20; 4.01] (p=0.97)
Apr-Sep	-1.17 [-3.24; 0.94] (p=0.53)	0.94 [-0.86; 2.78] (p=0.67)	-1.03 [-4.50; 2.56] (p=1.00)	1.29 [-1.74; 4.41] (p=0.97)
PM10				
>75th	-0.40 [-2.81; 2.07] (p=0.70)	1.06 [-0.69; 2.83] (p=0.33)	-1.28 [-5.32; 2.93] (p=0.85)	0.60 [-2.31; 3.60] (p=0.15)
≤ 75th	-0.93 [-2.66; 0.84] (p=0.70)	2.30 [0.37; 4.26] (p=0.33)	-0.85 [-3.78; 2.17] (p=0.85)	3.73 [0.45; 7.12] (p=0.15)
NO2				
>75th	-2.22 [-4.70; 0.32] (p=0.26)	0.92 [-0.94; 2.82] (p=0.61)	-2.25 [-6.40; 2.07] (p=0.55)	0.55 [-2.55; 3.75] (p=0.36)
≤ 75th	-0.59 [-2.44; 1.30] (p=0.26)	1.53 [-0.07; 3.16] (p=0.61)	-0.79 [-3.93; 2.45] (p=0.55)	2.39 [-0.32; 5.17] (p=0.36)
O3				
>75th	-2.20 [-4.54; 0.21] (p=0.12)	0.55 [-1.42; 2.56] (p=0.42)	-4.63 [-8.49; -0.60] (p=0.03)	0.74 [-2.58; 4.18] (p=0.72)
≤ 75th	-0.08 [-1.77; 1.64] (p=0.12)	1.52 [0.14; 2.92] (p=0.42)	0.49 [-2.38; 3.45] (p=0.03)	1.46 [-0.88; 3.85] (p=0.72)
PSC				
>75th	-0.23 [-2.85; 2.47] (p=0.61)	1.38 [-0.49; 3.28] (p=0.34)	-2.95 [-7.21; 1.51] (p=0.38)	0.77 [-2.36; 4.00] (p=0.31)
≤ 75th	-1.00 [-2.88; 0.93] (p=0.61)	2.70 [0.64; 4.79] (p=0.34)	-0.75 [-3.92; 2.54] (p=0.38)	3.14 [-0.32; 6.72] (p=0.31)
		Lag2-3		
Season				
Oct-Mar	-1.05 [-3.07; 1.00] (p=0.31)	0.28 [-1.26; 1.85] (p=0.91)	-2.07 [-5.44; 1.43] (p=0.08)	0.38 [-2.20; 3.03] (p=0.60)
Apr-Sep	0.45 [-1.67; 2.62] (p=0.31)	0.42 [-1.24; 2.11] (p=0.91)	2.33 [-1.28; 6.06] (p=0.08)	-0.64 [-3.42; 2.23] (p=0.60)
PM10				
>75th	-0.84 [-3.14; 1.52] (p=0.58)	-0.52 [-2.12; 1.11] (p=0.13)	-1.09 [-4.99; 2.96] (p=0.43)	-2.23 [-4.94; 0.54] (p=0.02)
≤ 75th	-0.09 [-1.82; 1.67] (p=0.58)	1.08 [-0.40; 2.57] (p=0.13)	0.72 [-2.21; 3.75] (p=0.43)	1.86 [-0.65; 4.42] (p=0.02)
NO2				
>75th	-0.09 [-2.55; 2.43] (p=0.78)	0.82 [-0.88; 2.56] (p=0.45)	0.59 [-3.56; 4.92] (p=0.77)	-0.23 [-3.08; 2.71] (p=0.85)
≤ 75th	-0.48 [-2.16; 1.23] (p=0.78)	0.02 [-1.36; 1.42] (p=0.45)	-0.12 [-2.98; 2.82] (p=0.77)	0.11 [-2.24; 2.51] (p=0.85)
O3				
>75th	-0.22 [-2.71; 2.34] (p=0.94)	-0.87 [-2.83; 1.14] (p=0.15)	0.18 [-4.01; 4.55] (p=0.99)	-1.89 [-5.18; 1.51] (p=0.20)
≤ 75th	-0.33 [-1.98; 1.34] (p=0.94)	0.78 [-0.51; 2.10] (p=0.15)	0.15 [-2.64; 3.02] (p=0.99)	0.60 [-1.58; 2.83] (p=0.20)
PSC				
>75th	-0.70 [-3.10; 1.77] (p=0.69)	0.34 [-1.53; 2.25] (p=0.98)	-0.33 [-4.40; 3.92] (p=0.82)	-0.63 [-3.73; 2.58] (p=0.64)
≤ 75th	-0.16 [-1.81; 1.52] (p=0.69)	0.37 [-0.94; 1.70] (p=0.98)	0.21 [-2.60; 3.10] (p=0.82)	0.23 [-1.98; 2.50] (p=0.64)
		Lag4-7		
Season				
Oct-Mar	0.35 [-1.98; 2.74] (p=0.88)	0.65 [-0.93; 2.26] (p=0.26)	2.32 [-1.69; 6.49] (p=0.94)	0.72 [-1.95; 3.46] (p=0.82)
Apr-Sep	0.61 [-1.53; 2.80] (p=0.88)	2.00 [0.26; 3.77] (p=0.26)	2.52 [-1.15; 6.33] (p=0.94)	1.20 [-1.73; 4.22] (p=0.82)
PM10				
>75th	-0.27 [-3.08; 2.63] (p=0.52)	1.95 [-0.01; 3.95] (p=0.41)	1.56 [-3.26; 6.62] (p=0.67)	1.05 [-2.25; 4.45] (p=1.00)
≤ 75th	0.73 [-1.03; 2.53] (p=0.52)	0.98 [-0.39; 2.38] (p=0.41)	2.76 [-0.28; 5.89] (p=0.67)	1.05 [-1.28; 3.43] (p=1.00)
NO2				
>75th	-0.37 [-3.29; 2.64] (p=0.49)	1.46 [-0.53; 3.49] (p=0.83)	1.45 [-3.57; 6.73] (p=0.65)	-0.17 [-3.52; 3.29] (p=0.40)
≤ 75th	0.77 [-0.99; 2.57] (p=0.49)	1.21 [-0.15; 2.59] (p=0.83)	2.78 [-0.26; 5.91] (p=0.65)	1.53 [-0.77; 3.89] (p=0.40)
O3				
>75th	-1.94 [-4.63; 0.83] (p=0.03)	0.45 [-1.75; 2.70] (p=0.39)	-0.47 [-5.04; 4.32] (p=0.13)	1.19 [-2.55; 5.07] (p=0.92)
≤ 75th	1.31 [-0.46; 3.11] (p=0.03)	1.56 [0.22; 2.92] (p=0.39)	3.51 [0.43; 6.68] (p=0.13)	0.96 [-1.31; 3.29] (p=0.92)
PSC				
>75th	-1.07 [-3.77; 1.70] (p=0.17)	0.88 [-1.31; 3.12] (p=0.68)	1.16 [-3.51; 6.05] (p=0.51)	1.52 [-2.19; 5.37] (p=0.76)
≤ 75th	1.04 [-0.75; 2.85] (p=0.17)	1.40 [0.08; 2.74] (p=0.68)	2.95 [-0.13; 6.13] (p=0.51)	0.87 [-1.36; 3.15] (p=0.76)