Daily visibility and mortality: assessment of health benefits from improving visibility in Hong Kong

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SUPPLEMENTARY MATERIAL

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Visibility effects derived from air pollutant data

In Hong Kong both visibility and air pollution data were available. This allowed us to verify whether the effect estimates for mortality associated with visibility were comparable to those derived from air pollutant data. For the verification, we completed the following steps, excluding accidental deaths:

1. We estimated the excess risk for daily mortality per 1 μgm^{-3} change in each pollutant using the same corresponding age–cause specific mortality core models developed for visibility data and denoted it by ER_p.

2. We regressed each concentration of pollutants against the visibility adjusted for temperature and humidity using multiple linear regression with all terms at lag 0–1 days (Vajanapoom et al., 2001). We treated visibility as linear while temperature and humidity were each fitted with natural cubic regression splines with 3 df. The coefficient associated with visibility represented the change of concentration of pollutant per unit change in visibility on average and denoted it by γ.

3. We obtained the estimated excess risk for daily mortality per IQR km change in visibility by multiplying $100\% \times ER_p \times \gamma \times IQR$ and denoted the resulting excess risk by $ER_{vp}\%$.

4. We then compared $ER_{vp}\%$ to ER% using the mean square errors defined as the mean of $[ER\% - ER_{vp}\%]^2$ (Yaffee and McGee, 2000).

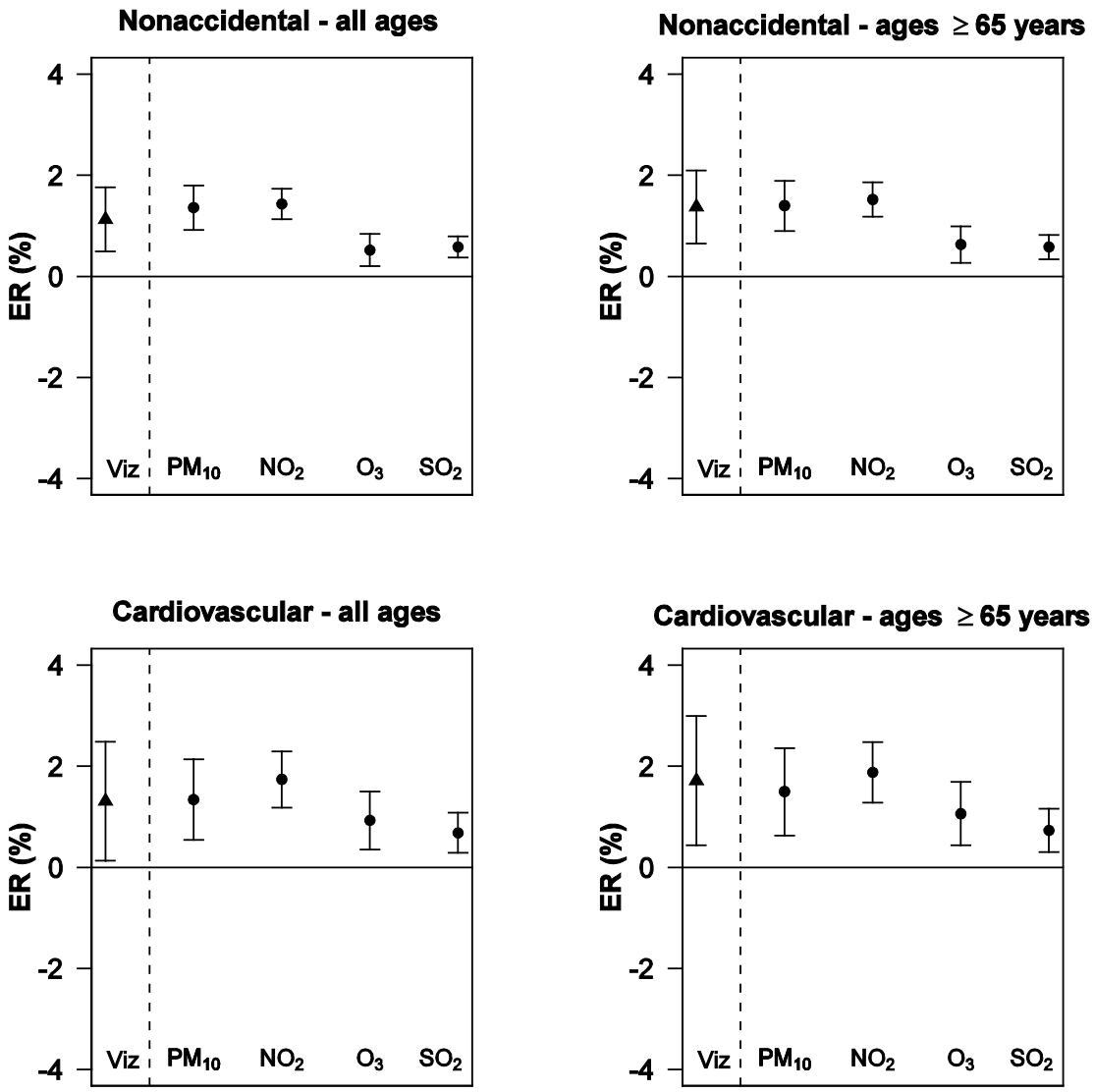
The gradients in concentrations of the four pollutants per 1km change in visibility were PM_{10}: –3.37, NO_2: –1.96, O_3: –2.07 and SO_2: –1.00 (data not shown). Mean square errors for predicted estimates of visibility on the mortality outcomes, excluding accidental mortality, derived from each pollutant compared to that of direct visibility, ranged from 0.04 to 1.01. The smallest mean square errors were found for PM_{10} (0.04) followed by NO_2 (0.15), O_3

(0.84) and SO_2 (1.01) (data not shown). The ER% for daily mortality per IQR km decrease in visibility predicted from PM_{10} were closest to those derived from visibility directly across all mortality outcomes (Appendices 1 and 2).

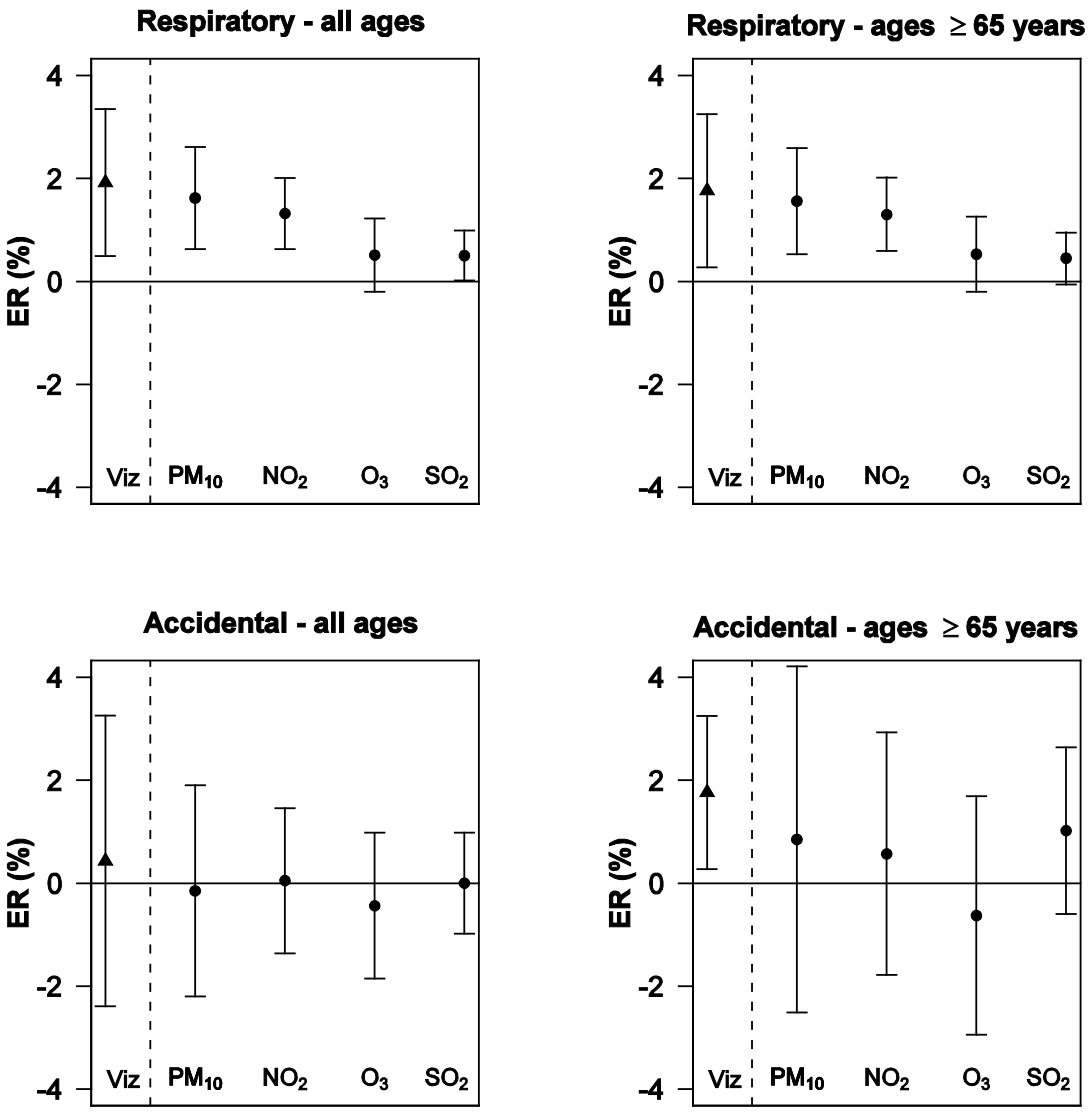
Exposure–response relationships

To examine the exposure–response relation between visibility and daily mortality we added a penalized cubic regression splines smoothing function for visibility at lag 0–1 to the core model using 2 degrees of freedom.

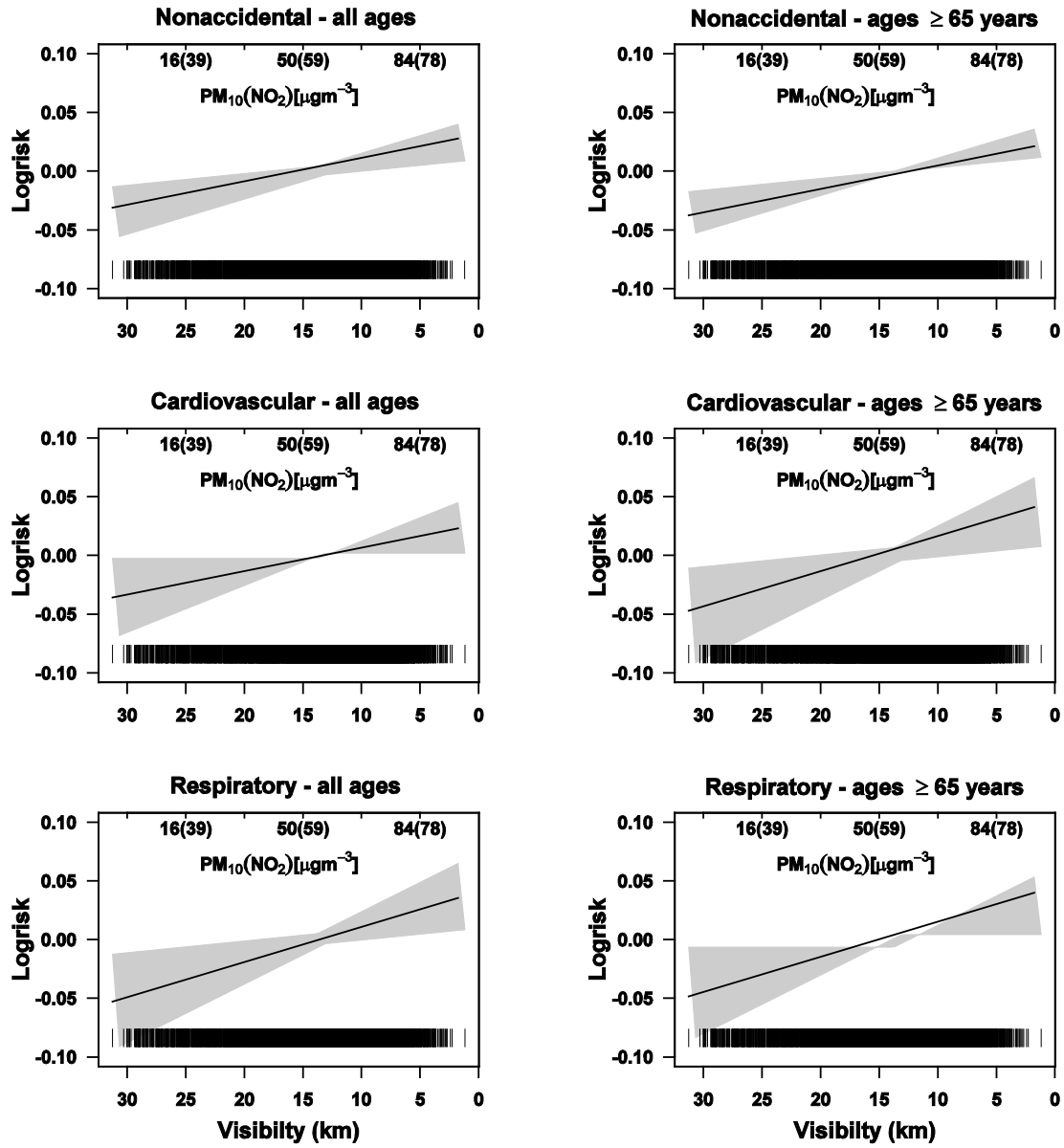
The log–risk for mortality decreased monotonically as a function of the visibility for lag 0–1, indicating a negative association between mortality and the visibility range. The levels of visibility at 5km, 15km and 25km corresponding to concentrations of PM_{10} (95% CI) in μgm^{-3} were 84 (83 to 85), 50 (49 to 51), and 16 (15 to 18) and of NO_2 (95% CI) in μgm^{-3} were 78 (77 to 80), 59 (58 to 60), and 39 (37 to 41) [Appendix 3].



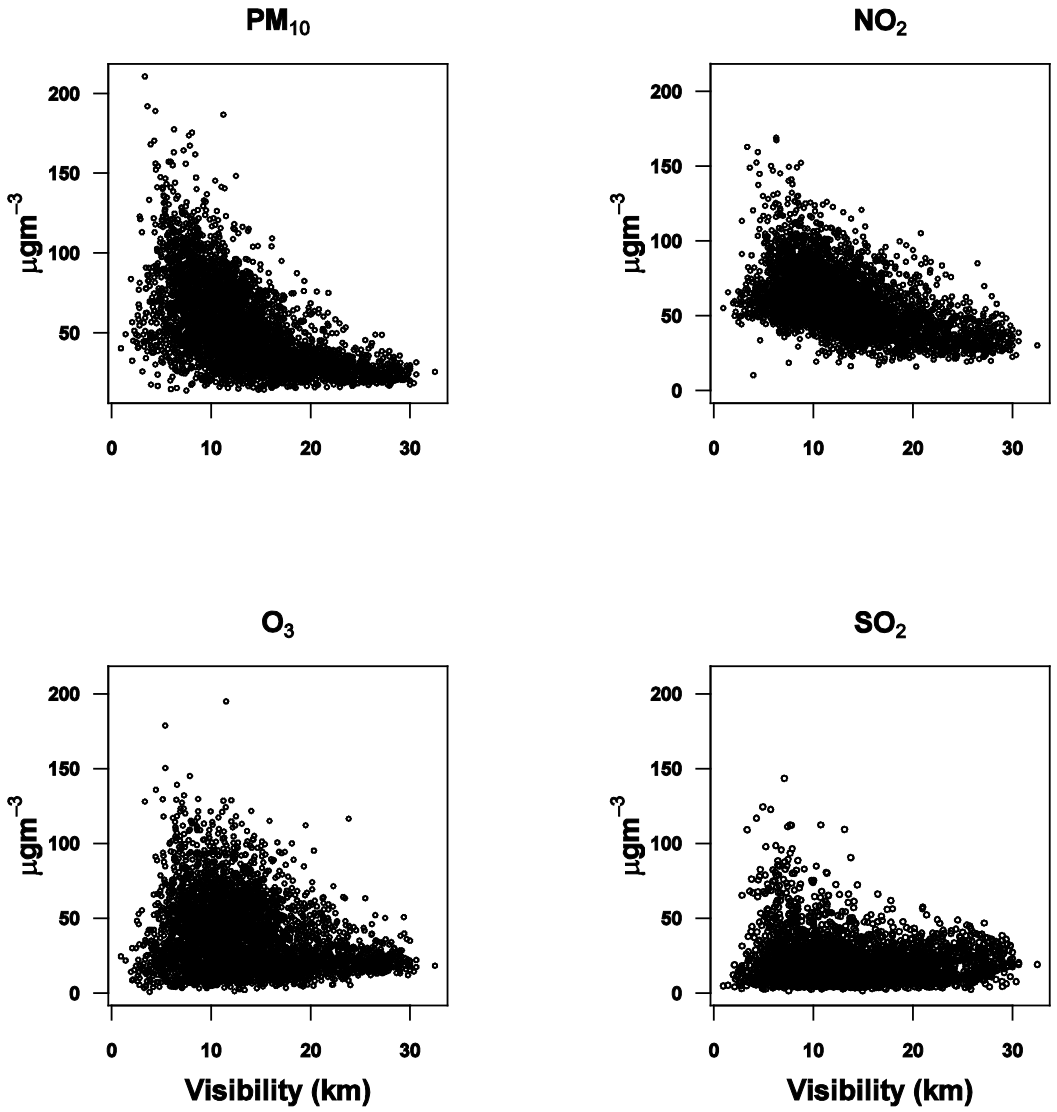
Appendix 1. Estimated excess risks (ER%) for daily mortality and associated 95% confidence intervals per interquartile range decrease in visibility (6.5km) at lag 0–1 days with comparison between ER% derived from visibility data (Viz) and from concentrations of air pollutants data.



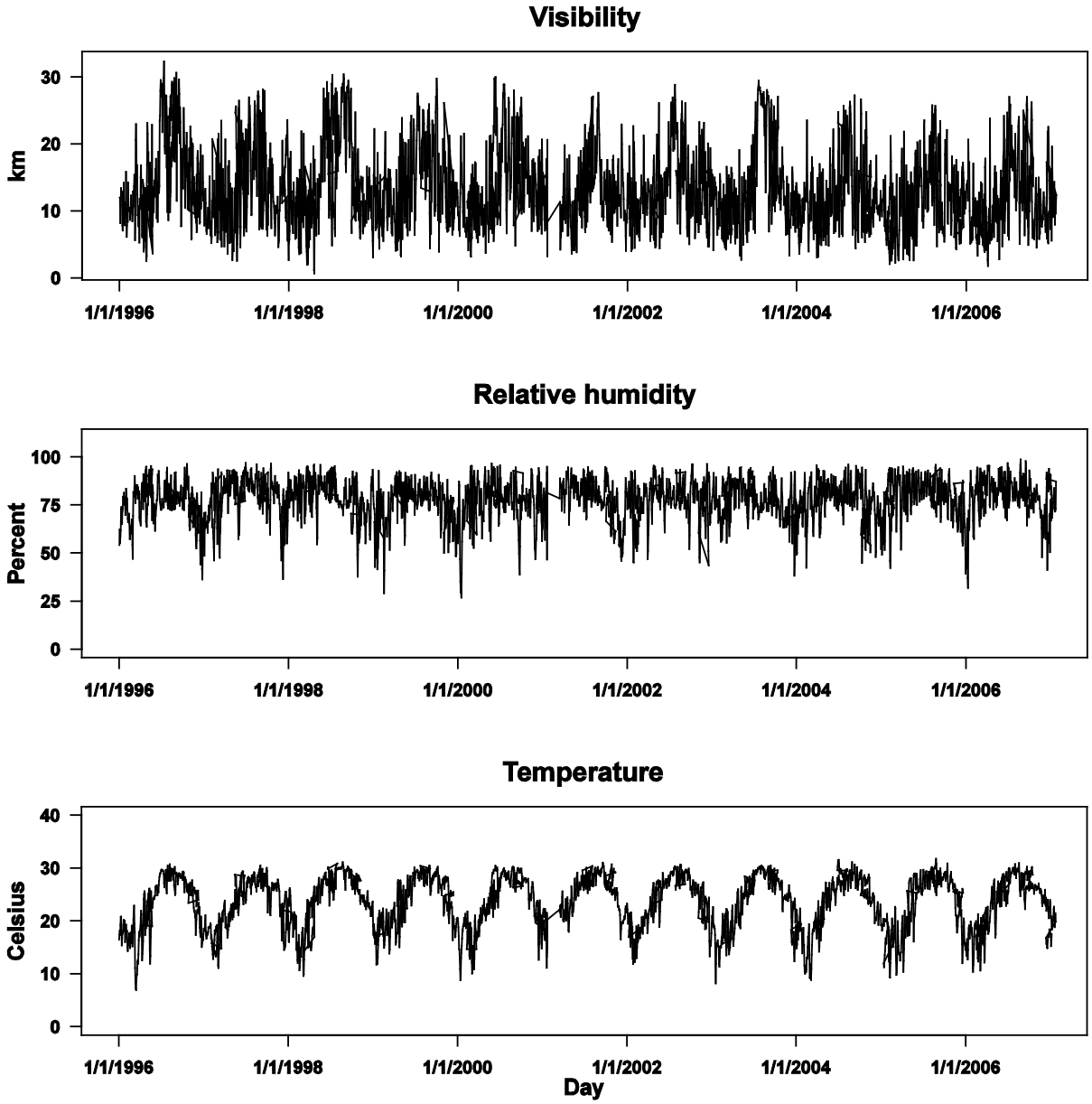
Appendix 2. Estimated excess risks (ER%) for daily mortality and associated 95% confidence intervals per interquartile range decrease in visibility (6.5km) at lag 0–1 days with comparison between ER% derived from visibility data (Viz) and from concentrations of air pollutants data.



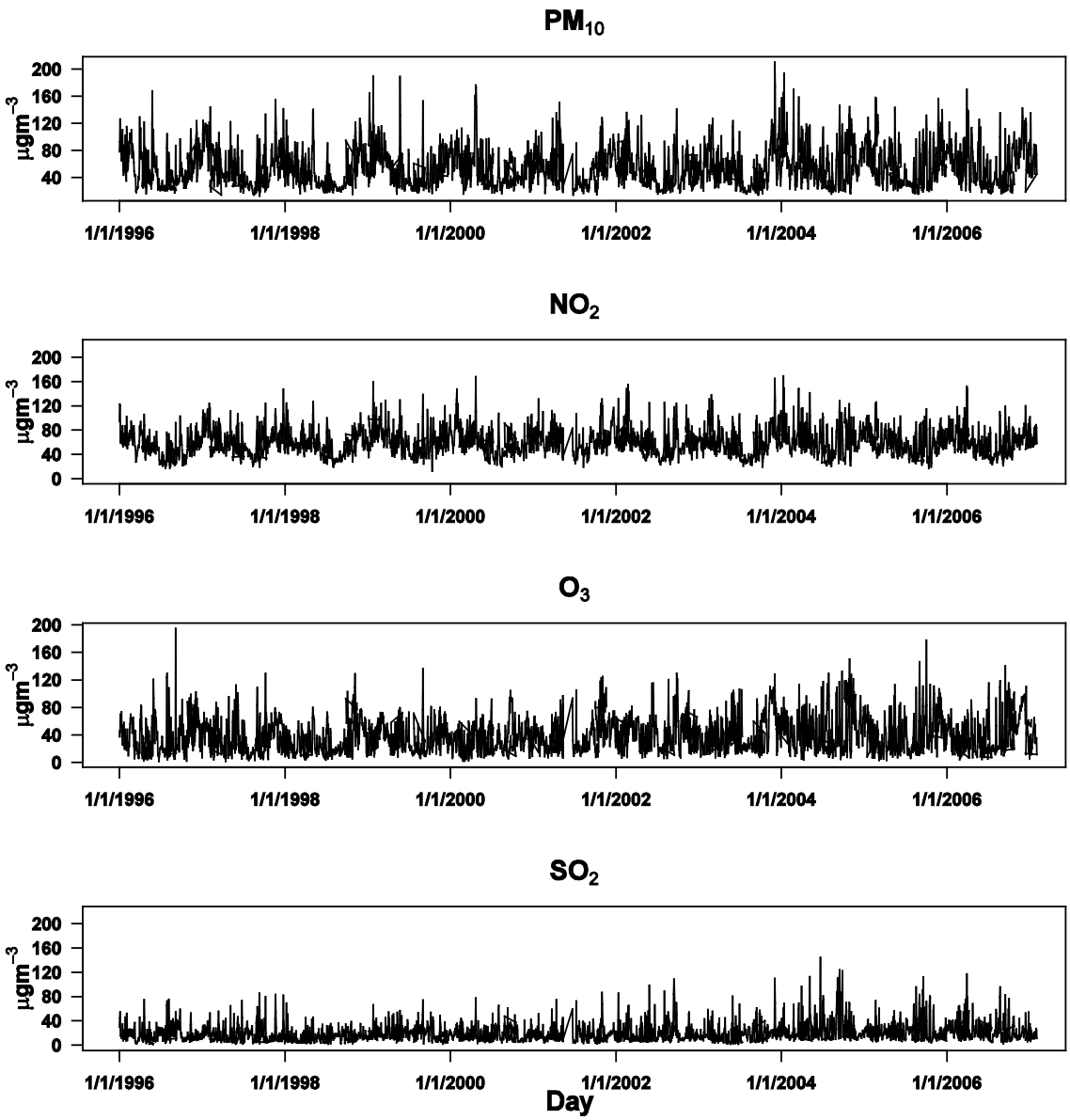
Appendix 3. Estimated exposure–response relationships for visibility with trends 4 degrees of freedom (df), temperature (3 df) and humidity (3 df) and visibility (2 df) at lag 0–1 days.



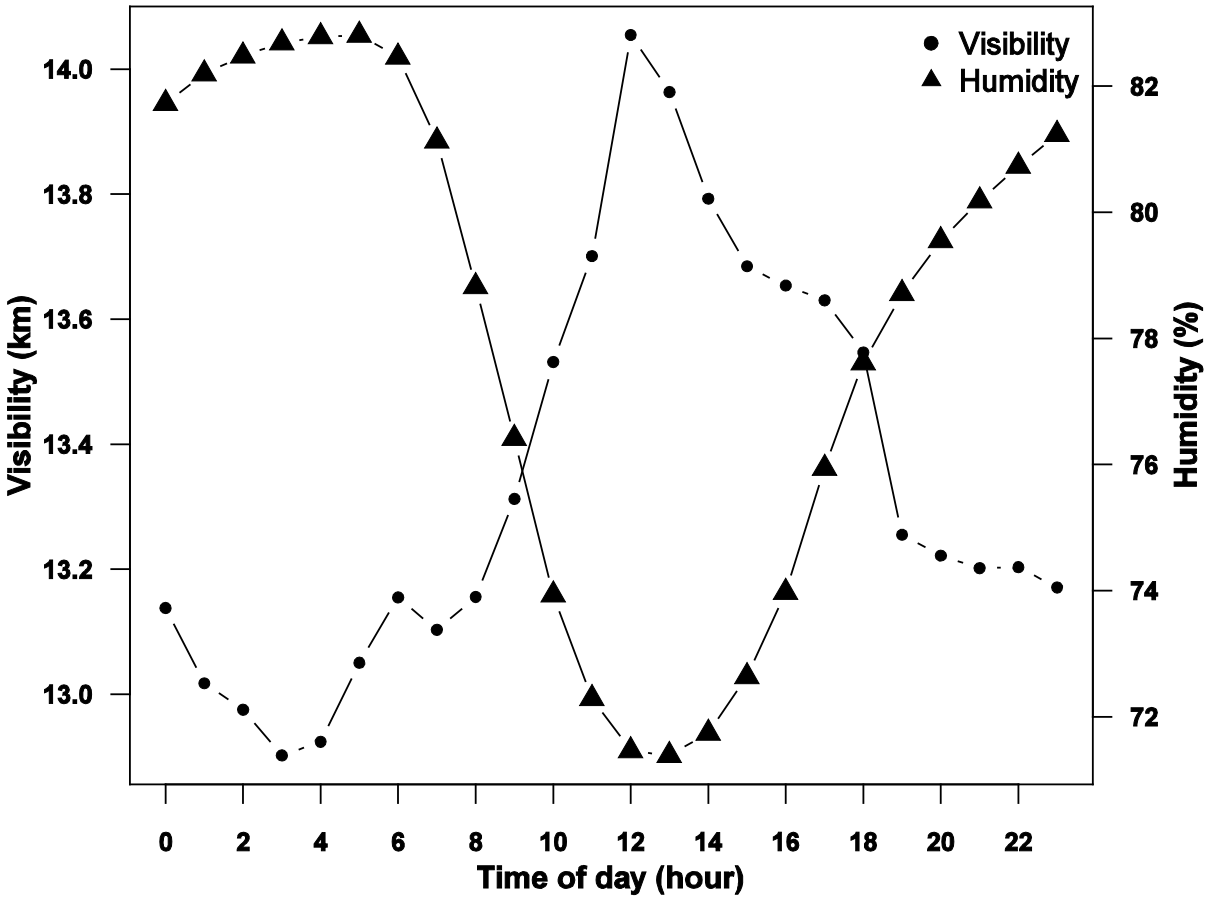
Appendix 4. Scatter plots of daily mean visibility in kilometer (km) against particulate matter with aerodynamic diameter ≤ 10µm (PM_{10}), nitrogen dioxide (NO_2), ozone (O_3) and sulfur dioxide (SO_2) in microgram per cubic meter (μgm^{-3}) in Hong Kong, 1996–2006.



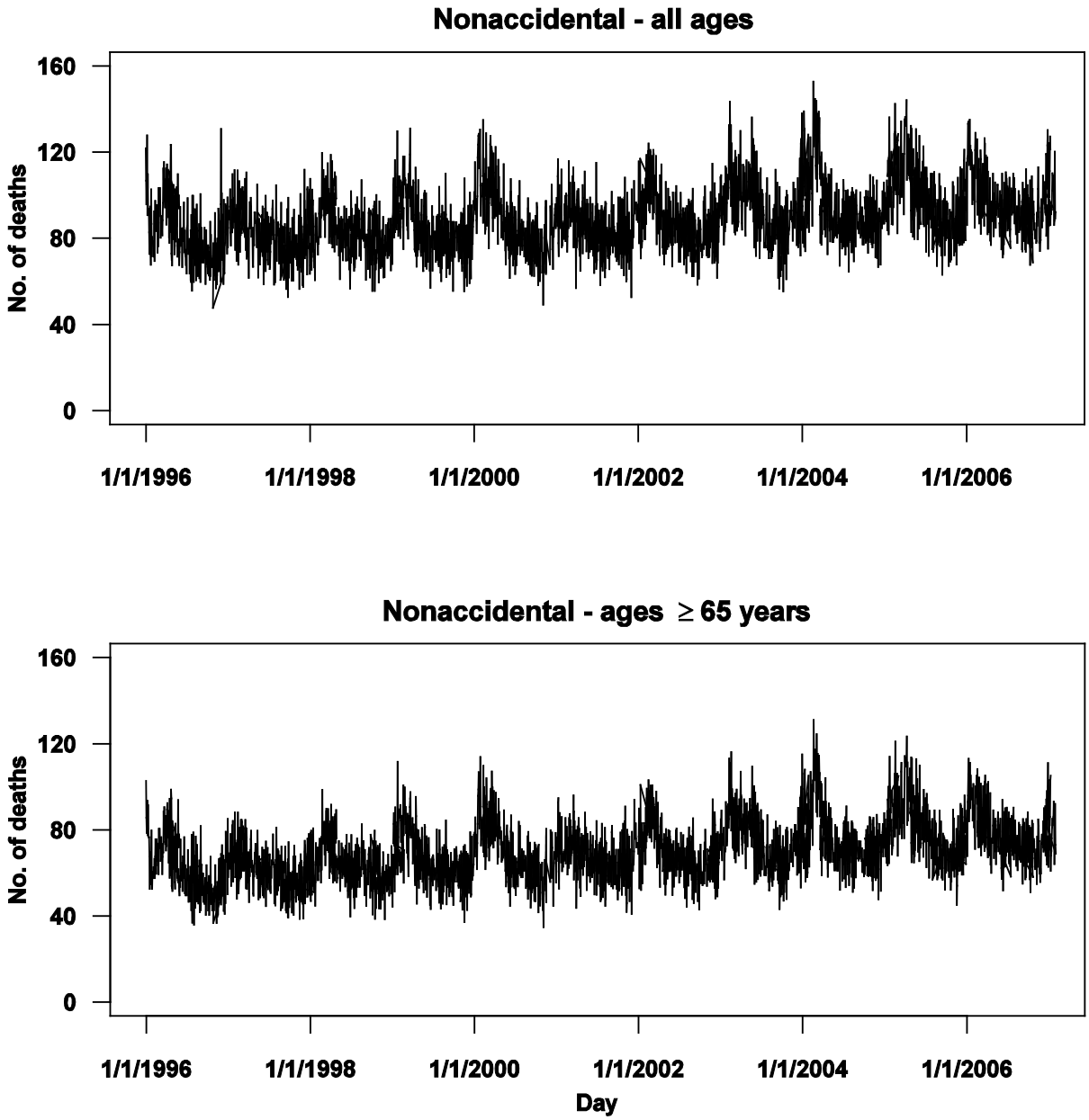
Appendix 5. Daily mean visibility in kilometers (km), relative humidity and temperature in Hong Kong, 1996–2006.



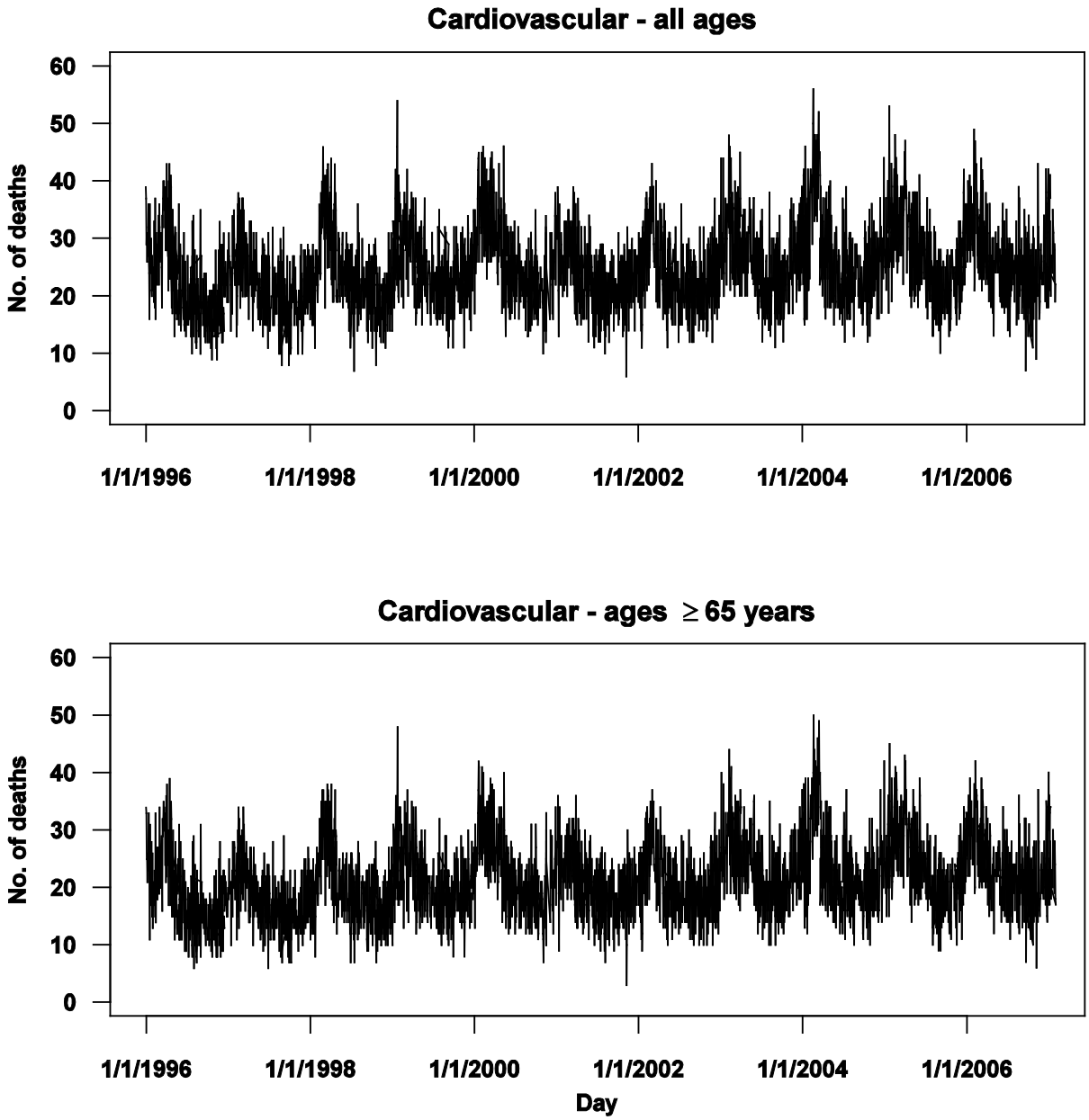
Appendix 6. Time series plots of the four air pollutant data in Hong Kong, 1996–2006.



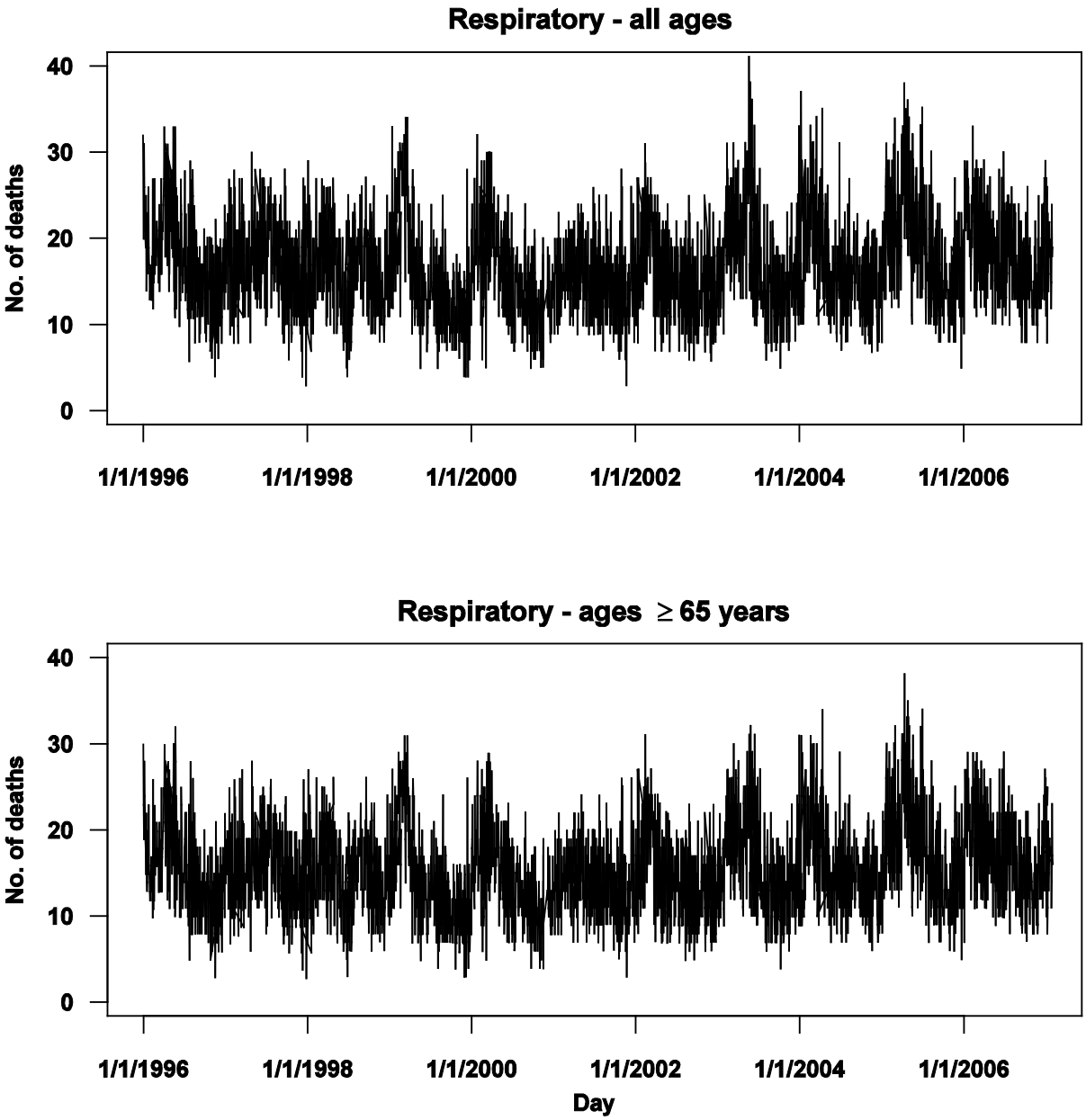
Appendix 7. Diurnal variation of visibility and relative humidity in Hong Kong, 1996–2006.



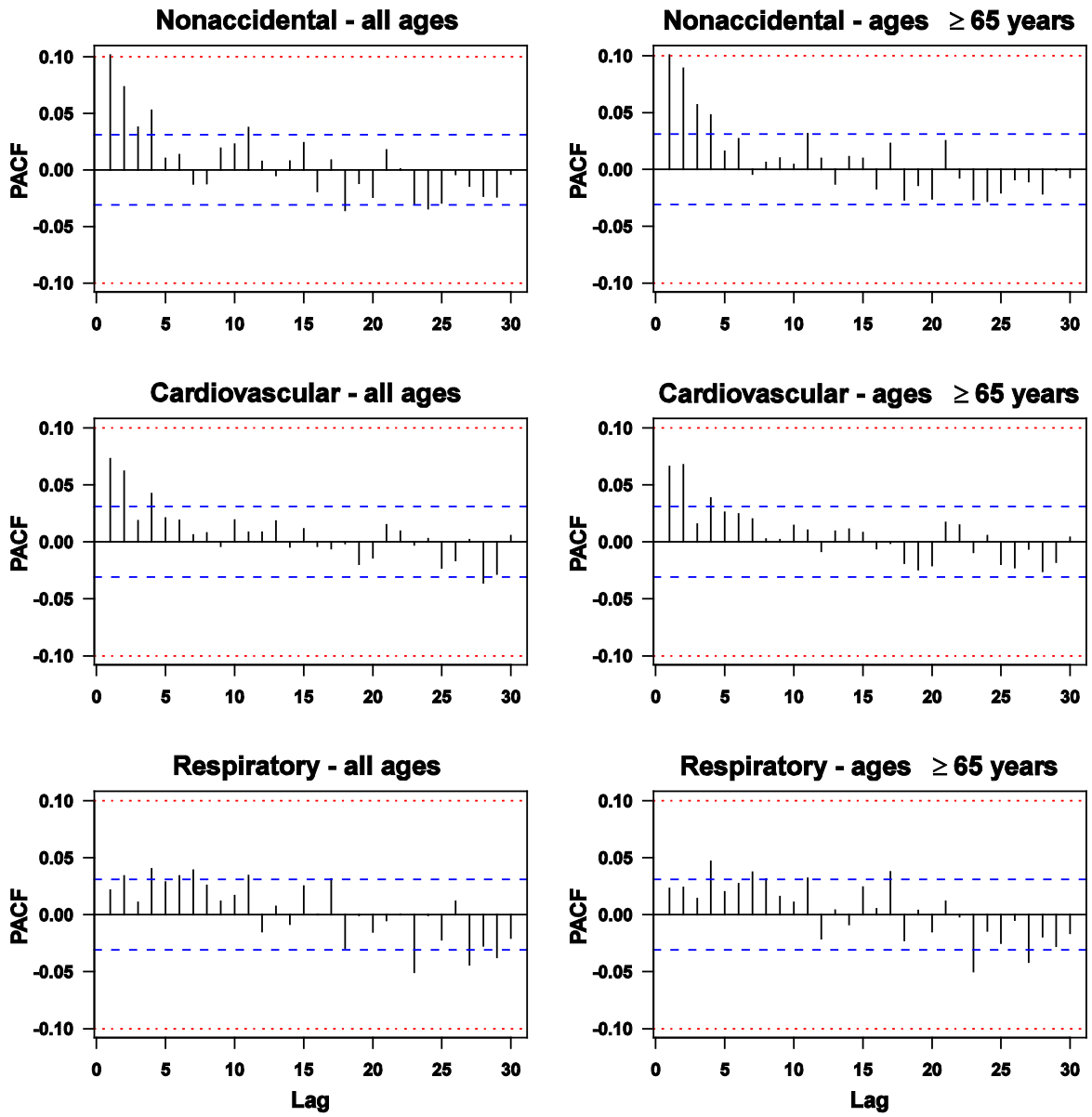
Appendix 8. Time series plots of nonaccidental mortality in Hong Kong, 1996–2006.



Appendix 9. Time series plots of cardiovascular mortality in Hong Kong, 1996–2006.



Appendix 10. Time series plots of respiratory mortality in Hong Kong, 1996–2006.



Appendix 11. Partial autocorrelation function (PACF) plots of the core models with the trends 4 degrees of freedom (df), temperature (3 df) and humidity (3 df) at lag 0–1 days.

Appendix 12.
Estimated excess risks (ER%) for daily mortality and associated 95% confidence intervals (CI) per interquartile range decrease in visibility (6.5km) at lag 0–1days for nonaccidental mortality at ages 65 years and over compared with sensitivity analyses.

	ER%	95% CI
Main analysis with 4 degrees of freedom for trends	1.37	0.65 to 2.09
1. Degrees of freedom for trends		
a. 5	1.21	0.50 to 1.91
b. 3	1.16	0.45 to 1.87
2. Exclusion of visibility with cut-off limit for humidity (%)		
a. > 90	1.32	0.62 to 2.02
b. > 80	[0.87]	0.16 to 1.58
3. Metric used for visibility		
a. mean based on the three measurements recorded at 10:00, 14:00 and 16:00 hours	[0.88]	0.28 to 1.48
b. 24 hour maximum	[0.97]	0.41 to 1.53
4. Exclusion of extreme visibility range		
a. < 8 km	1.17	0.34 to 2.00
b. < the 25th percentile	1.12	0.17 to 2.06
c. < the 5th percentile	1.24	0.48 to 2.00
5. Adjustment for air pollutants		
a. PM_{10}	[–0.23]	–1.27 to 0.81
b. NO_2	[–0.23]	–1.04 to 0.59
c. O_3	[1.01]	0.19 to 1.83
d. SO_2	[0.91]	0.15 to 1.66
6. Average lag 0–2 days for temperature and humidity	1.46	0.76 to 2.16
7. Natural cubic regression splines	1.38	0.65 to 2.11

Note: ER% in squared brackets when it changed >20% from the main analysis.

Appendix 13.
Estimated excess risks (ER%) for daily mortality and associated 95% confidence intervals (CI) per interquartile range decrease in visibility (6.5km) at lag 0–1days for cardiovascular mortality at all ages compared with sensitivity analyses.

	ER%	95% CI
Main analysis with 4 degrees of freedom for trends	1.31	0.13 to 2.49
1. Degrees of freedom for trends		
a. 5	1.16	–0.00 to 2.32
b. 3	[0.97]	–0.19 to 2.14
2. Exclusion of visibility with cut-off limit for humidity (%)		
a. > 90	1.23	0.08 to 2.38
b. > 80	[0.85]	–0.32 to 2.01
3. Metric used for visibility		
a. mean based on the three measurements recorded at 10:00, 14:00 and 16:00 hours	[0.73]	–0.25 to 1.71
b. 24 hour maximum	1.11	0.20 to 2.02
4. Exclusion of extreme visibility range		
a. < 8 km	[0.87]	–0.49 to 2.23
b. < the 25th percentile	[0.97]	–0.58 to 2.51
c. < the 5th percentile	1.23	–0.01 to 2.48
5. Adjustment for air pollutants		
a. PM_{10}	[–0.19]	–1.87 to 1.48
b. NO_2	[–0.54]	–1.87 to 0.79
c. O_3	[0.57]	–0.75 to 1.89
d. SO_2	[0.74]	–0.49 to 1.98
6. Average lag 0–2 days for temperature and humidity	1.33	0.18 to 2.48
7. Natural cubic regression splines	1.26	0.06 to 2.46

Note: ER% in squared brackets when it changed >20% from the main analysis.

Appendix 14.
Estimated excess risks (ER%) for daily mortality and associated 95% confidence intervals (CI) per interquartile range decrease in visibility (6.5km) at lag 0–1days for cardiovascular mortality at ages 65 years and over compared with sensitivity analyses.

	ER%	95% CI
Main analysis with 4 degrees of freedom for trends	1.72	0.44 to 3.00
1. Degrees of freedom for trends		
a. 5	1.59	0.33 to 2.86
b. 3	1.42	0.14 to 2.69
2. Exclusion of visibility with cut-off limit for humidity (%)		
a. > 90	1.62	0.38 to 2.87
b. > 80	[1.09]	–0.18 to 2.36
3. Metric used for visibility		
a. mean based on the three measurements recorded at 10:00, 14:00 and 16:00 hours	[0.98]	–0.09 to 2.04
b. 24 hour maximum	[1.27]	0.28 to 2.26
4. Exclusion of extreme visibility range		
a. < 8 km	[1.35]	–0.13 to 2.83
b. < the 25th percentile	[1.24]	–0.44 to 2.92
c. < the 5th percentile	1.71	0.36 to 3.06
5. Adjustment for air pollutants		
a. PM_{10}	[0.28]	–1.54 to 2.10
b. NO_2	[0.21]	–1.65 to 1.24
c. O_3	[0.93]	–0.50 to 2.36
d. SO_2	[1.15]	–0.20 to 2.49
6. Average lag 0–2 days for temperature and humidity	1.75	0.50 to 3.00
7. Natural cubic regression splines	1.67	0.37 to 2.98

Note: ER% in squared brackets when it changed >20% from the main analysis.

Appendix 15.
Estimated excess risks (ER%) for daily mortality and associated 95% confidence intervals (CI) per interquartile range decrease in visibility (6.5km) at lag 0–1days for respiratory mortality at all ages compared with sensitivity analyses.

	ER%	95% CI
Main analysis with 4 degrees of freedom for trends	1.92	0.49 to 3.35
1. Degrees of freedom for trends		
a. 5	1.58	0.18 to 2.99
b. 3	[1.35]	–0.03 to 2.73
2. Exclusion of visibility with cut-off limit for humidity (%)		
a. > 90	1.86	0.48 to 3.25
b. > 80	1.64	0.23 to 3.04
3. Metric used for visibility		
a. mean based on the three measurements recorded at 10:00, 14:00 and 16:00 hours	[0.93]	–0.26 to 2.11
b. 24 hour maximum	[1.01]	–0.11 to 2.13
4. Exclusion of extreme visibility range		
a. < 8 km	1.82	0.17 to 3.47
b. < the 25th percentile	2.23	0.36 to 4.10
c. < the 5th percentile	1.92	0.42 to 3.42
5. Adjustment for air pollutants		
a. PM_{10}	[0.50]	–1.54 to 2.55
b. NO_2	[0.79]	–0.83 to 2.41
c. O_3	1.91	0.31 to 3.52
d. SO_2	1.62	0.12 to 3.12
6. Average lag 0–2 days for temperature and humidity	2.02	0.62 to 3.42
7. Natural cubic regression splines	2.00	0.54 to 3.45

Note: ER% in squared brackets when it changed >20% from the main analysis.

Appendix 16.
Estimated excess risks (ER%) for daily mortality and associated 95% confidence intervals (CI) per interquartile range decrease in visibility (6.5km) at lag 0–1days for respiratory mortality at ages 65 years and over compared with sensitivity analyses.

	ER%	95% CI
Main analysis with 4 degrees of freedom for trends	1.76	0.28 to 3.25
1. Degrees of freedom for trends		
a. 5	1.45	–0.02 to 2.92
b. 3	[1.24]	–0.20 to 2.68
2. Exclusion of visibility with cut-off limit for humidity (%)		
a. > 90	1.79	0.35 to 3.23
b. > 80	1.49	0.02 to 2.95
3. Metric used for visibility		
a. mean based on the three measurements recorded at 10:00, 14:00 and 16:00 hours	[0.80]	–0.44 to 2.03
b. 24 hour maximum	[0.96]	–0.20 to 2.12
4. Exclusion of extreme visibility range		
a. < 8 km	1.79	0.08 to 3.50
b. < the 25th percentile	[2.14]	0.20 to 4.09
c. < the 5th percentile	1.77	0.21 to 3.32
5. Adjustment for air pollutants		
a. PM_{10}	[0.31]	–1.81 to 2.42
b. NO_2	[0.62]	–1.07 to 2.30
c. O_3	1.67	–0.00 to 3.34
d. SO_2	1.51	–0.05 to 3.07
6. Average lag 0–2 days for temperature and humidity	1.87	0.41 to 3.32
7. Natural cubic regression splines	1.84	0.32 to 3.36

Note: ER% in squared brackets when it changed >20% from the main analysis.

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