

Characterising non-linear associations between airborne pollen counts and respiratory symptoms from the AirRater smartphone app in Tasmania, Australia: A case time series approach

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SUPPLEMENTARY MATERIAL – APPENDIX A

Table S1: Data characteristics of each pollen taxon and the environmental and air quality data over the study period Oct 29 2015 – Oct 29 2019. IQR = interquartile range, Q1 and Q3 = quartiles 1 and 3 respectively. For pollen taxa, % of total pollen denotes the % of the total pollen count comprised by that taxon over the four-year study period.

Pollen Taxa	% of total pollen	Min	Q1	Median	Q3	Max	IQR
<i>Acacia</i>	0.5	1	1	2	3	29	2
<i>Alnus</i>	1.5	1	1	3	6	155	5
Asteraceae	1.3	1	1	2	3	56	2
<i>Betula</i>	5	1	2	6	19	839	17
Brassicaceae	1	1	1	2	4	219	3
<i>Casuarina</i>	7.3	1	2	3	6	904	4
Cupressaceae	18	1	2	5	17	993	15
<i>Dodonaea</i>	4	1	2	4	18	372	16
Myrtaceae	7	1	2	3	7	345	5
Oleaceae	3	1	2	3	8	361	6
<i>Papaver</i>	0.6	1	1	2	5	295	4
Pinaceae	4.4	1	2	3	9	336	7
<i>Plantago</i>	16	1	2	3	7	1298	5
Poaceae	22	1	2	5	14	1111	12
Podocarpaceae	1	1	1	2	3	264	2
<i>Quercus</i>	0.7	1	1	2	7	133	6
<i>Rumex</i>	2.7	1	1	3	6	199	5
<i>Salix</i>	2.2	1	2	4	10	239	8
<i>Ulmus</i>	2.8	1	2	3	9	433	7

Variable	Min	Q1	Median	Q3	Max	IQR
Maximum temperature (°C)	-0.5	13.9	17.6	21.9	40.1	8.0
Minimum temperature (°C)	-7.6	5.5	8.9	12.2	38.4	6.7
Relative humidity (%)	17	62.6	71.3	80.5	100	17.9
Rainfall (mm)	0	0	0	1.4	140	1.4
PM _{2.5} (µg/m ³)	0	4	8	22	6990	18

Table S2. Relative Risk of AirRater symptom reporting for eye and nose symptoms for six pollen taxa over varying levels of exposure and lag periods. Numbers in brackets indicate the 95% confidence interval. Pollen concentrations are in grains/m³. The model controlled for PM_{2.5}, maximum and minimum temperature, relative humidity, and rainfall.

	Exposure level (grains/m ³)	Lag (days)			
		0	1	2	3
Poaceae	10	1.12 (1.07-1.18)	1.03 (0.99-1.07)	1.00 (0.96-1.03)	1.00 (0.96-1.05)
	30	1.29 (1.20-1.39)	1.10 (1.04-1.17)	1.00 (0.95-1.05)	0.93 (0.87-1.00)
	50	1.37 (1.26-1.49)	1.17 (1.10-1.25)	1.01 (0.95-1.07)	0.87 (0.80-0.94)
<i>Betula</i>	10	1.04 (0.97-1.12)	0.98 (0.93-1.03)	1.01 (0.96-1.06)	1.11 (1.04-1.19)
	30	1.18 (1.07-1.30)	1.01 (0.94-1.09)	1.01 (0.94-1.08)	1.10 (1.00-1.21)
	50	1.27 (1.12-1.44)	1.06 (0.96-1.18)	1.00 (0.91-1.09)	1.01 (0.88-1.17)
<i>Casuarina</i>	10	0.90 (0.85-0.96)	0.98 (0.94-1.03)	1.01 (0.97-1.05)	1.00 (0.94-1.05)
	30	1.07 (0.98-1.17)	1.04 (0.96-1.12)	1.02 (0.95-1.09)	1.01 (0.91-1.11)
	50	1.39 (1.20-1.62)	1.12 (0.98-1.27)	1.01 (0.90-1.14)	1.00 (0.85-1.17)
Cupressaceae	10	1.02 (0.97-1.08)	1.03 (0.98-1.07)	1.02 (0.98-1.06)	1.00 (0.95-1.06)
	30	1.09 (1.01-1.18)	1.10 (1.04-1.17)	1.07 (1.02-1.13)	1.02 (0.95-1.10)
	50	1.15 (1.04-1.26)	1.17 (1.09-1.26)	1.13 (1.06-1.21)	1.05 (0.95-1.15)
Myrtaceae	10	1.07 (1.02-1.13)	1.11 (1.07-1.15)	1.06 (1.02-1.09)	0.95 (0.91-1.00)
	30	1.17 (1.08-1.27)	1.13 (1.06-1.21)	1.05 (0.99-1.11)	0.96 (0.88-1.04)
	50	1.23 (1.10-1.39)	1.1 (0.99-1.21)	1.02 (0.93-1.12)	0.98 (0.87-1.11)
<i>Dodonaea</i>	10	1.23 (1.14-1.32)	1.02 (0.97-1.08)	0.94 (0.89-0.99)	0.92 (0.86-0.98)
	30	1.26 (1.14-1.39)	0.95 (0.88-1.03)	0.90 (0.84-0.96)	0.97 (0.89-1.07)
	50	1.12 (1.00-1.25)	0.88 (0.81-0.95)	0.89 (0.83-0.96)	1.08 (0.98-1.20)

Table S3. Relative Risk of AirRater symptom reporting for lung symptoms for individual pollen taxa over varying levels of exposure and lag periods. Numbers in brackets indicate the 95% confidence interval. Pollen concentrations are in grains/m³. Models controlled for PM_{2.5}, maximum and minimum temperature, relative humidity, and rainfall.

	Exposure (grains/m ³)	Lag (days)			
		0	1	2	3
Poaceae	10	1.19 (1.06-1.32)	1.05 (0.96-1.14)	0.99 (0.92-1.06)	0.97 (0.87-1.08)
	30	1.43 (1.21-1.68)	1.13 (1.00-1.29)	0.98 (0.88-1.09)	0.89 (0.76-1.04)
	50	1.52 (1.26-1.83)	1.21 (1.05-1.40)	1.00 (0.88-1.13)	0.85 (0.71-1.02)
<i>Betula</i>	10	1.06 (0.90-1.25)	0.96 (0.85-1.09)	0.96 (0.86-1.07)	1.03 (0.89-1.21)
	30	1.15 (0.91-1.45)	0.97 (0.81-1.16)	0.93 (0.79-1.09)	0.97 (0.77-1.22)
	50	1.20 (0.90-1.61)	1.02 (0.81-1.27)	0.94 (0.76-1.14)	0.91 (0.66-1.26)
<i>Casuarina</i>	10	0.93 (0.83-1.04)	1.05 (0.96-1.16)	1.03 (0.95-1.12)	0.92 (0.82-1.04)
	30	1.10 (0.92-1.33)	1.10 (0.94-1.27)	1.03 (0.90-1.18)	0.94 (0.78-1.14)
	50	1.39 (1.04-1.86)	1.10 (0.86-1.42)	1.00 (0.80-1.26)	1.01 (0.74-1.37)
Cupressaceae	10	1.00 (0.89-1.12)	1.02 (0.93-1.11)	1.04 (0.96-1.13)	1.06 (0.95-1.19)
	30	1.09 (0.92-1.30)	1.16 (1.02-1.32)	1.14 (1.02-1.27)	1.06 (0.90-1.24)
	50	1.19 (0.97-1.46)	1.34 (1.14-1.56)	1.23 (1.07-1.42)	1.00 (0.81-1.23)
Myrtaceae	10	1.08 (0.98-1.20)	1.04 (0.96-1.13)	0.95 (0.88-1.02)	0.83 (0.75-0.93)
	30	1.15 (0.97-1.37)	0.95 (0.83-1.10)	0.88 (0.78-1.00)	0.88 (0.74-1.05)
	50	1.15 (0.88-1.49)	0.90 (0.73-1.12)	0.89 (0.73-1.08)	1.02 (0.78-1.33)
<i>Dodonaea</i>	10	1.37 (1.17-1.61)	1.03 (0.92-1.17)	0.96 (0.87-1.07)	1.03 (0.89-1.19)
	30	1.49 (1.19-1.86)	1.05 (0.88-1.24)	0.95 (0.82-1.09)	1.01 (0.82-1.23)
	50	1.27 (0.98-1.63)	1.02 (0.85-1.24)	0.95 (0.80-1.13)	0.97 (0.77-1.23)

Table S4. Relative Risk of AirRater symptom reporting (eye, nose and lung symptoms combined) for total pollen concentrations at varying levels of exposure and lag periods, with and without interactions with PM_{2.5}. Results with interactions are shown with the interaction centred at PM_{2.5} concentrations of 3, 25, 50 and 100 µg/m³. Numbers in brackets indicate the 95% confidence interval. Pollen concentrations are in grains/m³, while PM_{2.5} concentrations are µg/m³. The model controlled for maximum and minimum temperature, relative humidity, and rainfall.

		Lag (days)			
Exposure level		0	1	2	3
No interaction	10	1.07 (1.06-1.08)	1.02 (1.01-1.03)	1.00 (0.99-1.01)	1.00 (0.99-1.02)
	30	1.21 (1.17-1.26)	1.05 (1.02-1.08)	1.00 (0.98-1.02)	1.01 (0.98-1.05)
	50	1.32 (1.25-1.39)	1.08 (1.04-1.12)	1.00 (0.97-1.04)	1.02 (0.97-1.07)
PM = 3	10	1.06 (1.04-1.07)	1.02 (1.01-1.03)	1.01 (1.00-1.01)	1.00 (0.98-1.01)
	30	1.17 (1.13-1.22)	1.07 (1.04-1.10)	1.02 (0.99-1.04)	0.99 (0.96-1.03)
	50	1.26 (1.20-1.33)	1.11 (1.07-1.16)	1.03 (0.99-1.07)	0.99 (0.94-1.04)
PM = 25	10	1.07 (1.06-1.08)	1.02 (1.01-1.03)	1.00 (0.99-1.01)	1.01 (0.99-1.02)
	30	1.21 (1.17-1.26)	1.05 (1.02-1.08)	1.00 (0.98-1.02)	1.02 (0.98-1.05)
	50	1.32 (1.26-1.39)	1.08 (1.04-1.12)	1.01 (0.97-1.04)	1.03 (0.98-1.08)
PM = 50	10	1.08 (1.07-1.10)	1.01 (1.00-1.02)	0.99 (0.98-1.00)	1.02 (1.01-1.03)
	30	1.26 (1.21-1.31)	1.02 (0.99-1.05)	0.98 (0.96-1.01)	1.05 (1.02-1.09)
	50	1.39 (1.32-1.47)	1.04 (1.00-1.09)	0.98 (0.95-1.02)	1.07 (1.02-1.13)
PM = 100	10	1.11 (1.09-1.13)	0.99 (0.97-1.00)	0.98 (0.97-0.99)	1.04 (1.03-1.06)
	30	1.35 (1.28-1.42)	0.97 (0.94-1.01)	0.95 (0.91-0.98)	1.12 (1.07-1.18)
	50	1.54 (1.42-1.66)	0.98 (0.93-1.03)	0.93 (0.89-0.98)	1.17 (1.10-1.26)

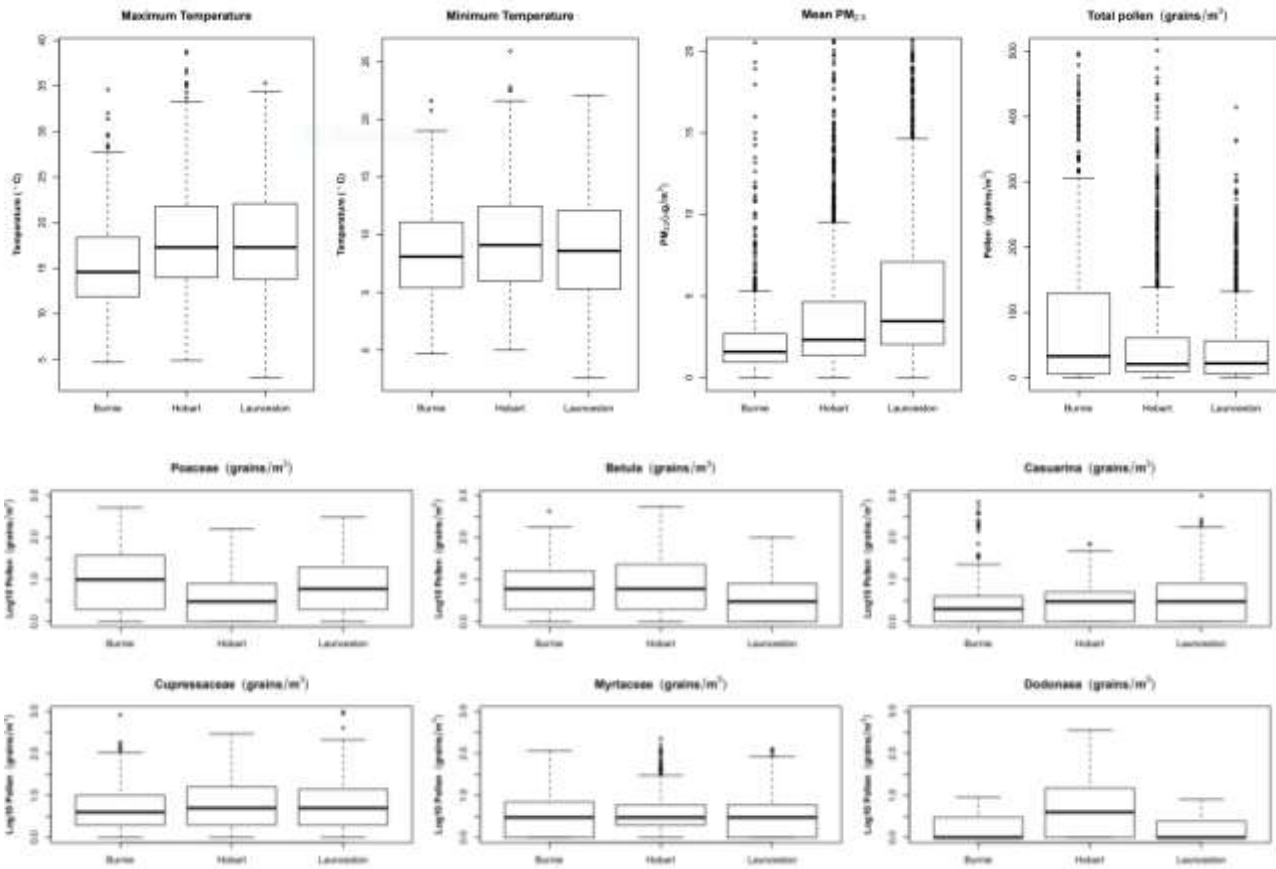


Figure S1. Box-and-whisker plots showing exposure to pollen, particulate and meteorological variables over the study period for Tasmania's three major population centres: Hobart (south), Launceston (inland north) and Burnie (coastal north-west). Pollen data are plotted on a log scale for ease of display.

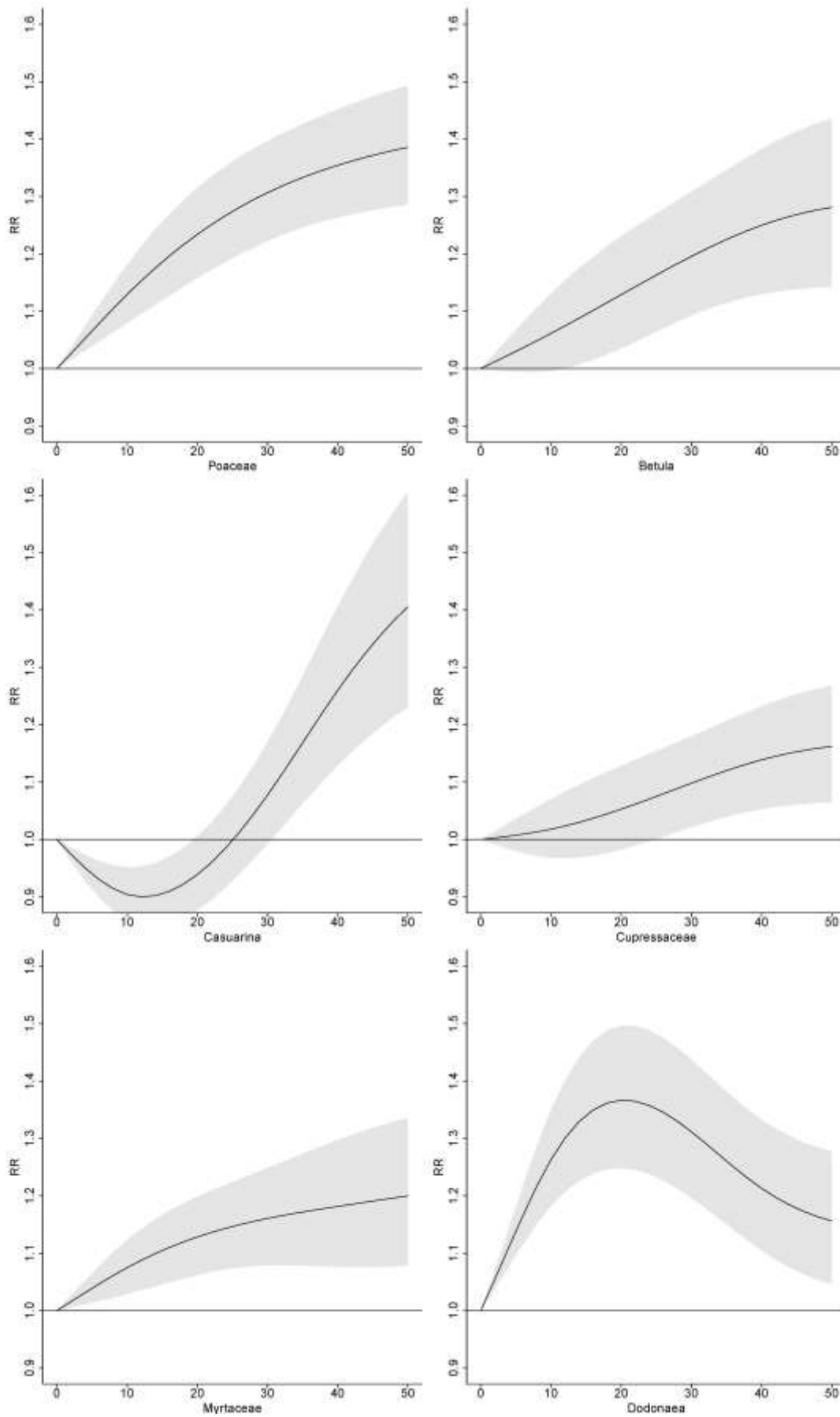


Figure S2: Same-day associations between individual pollen taxa and eye, nose and lung symptoms. Associations are presented as the Risk Ratio (RR) and the grey shading shows the 95% confidence interval.

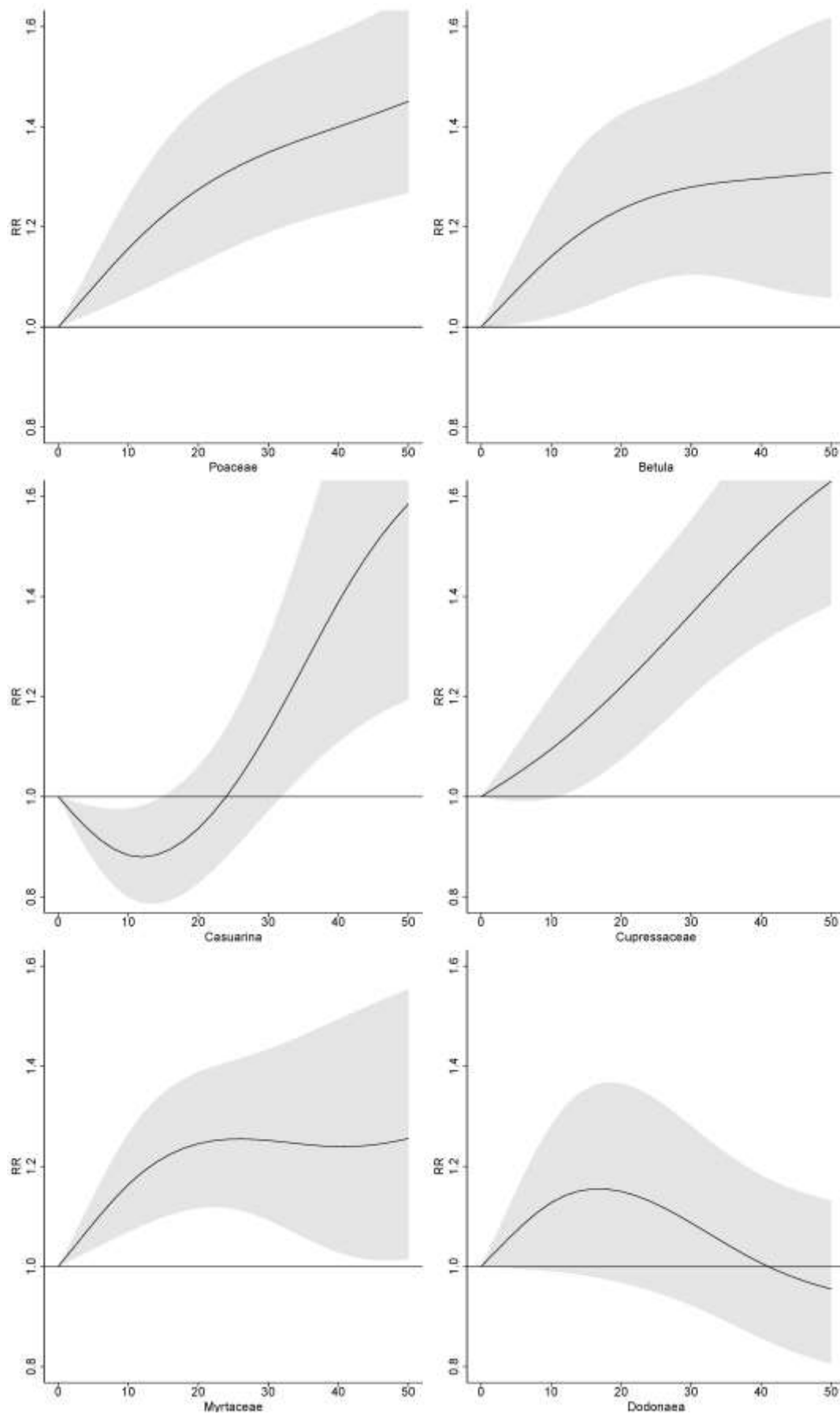


Figure S3: Cumulative (three-day) associations between individual pollen taxa and eye, nose and lung symptoms. Associations are presented as the Risk Ratio (RR) and the grey shading shows the 95% confidence interval.

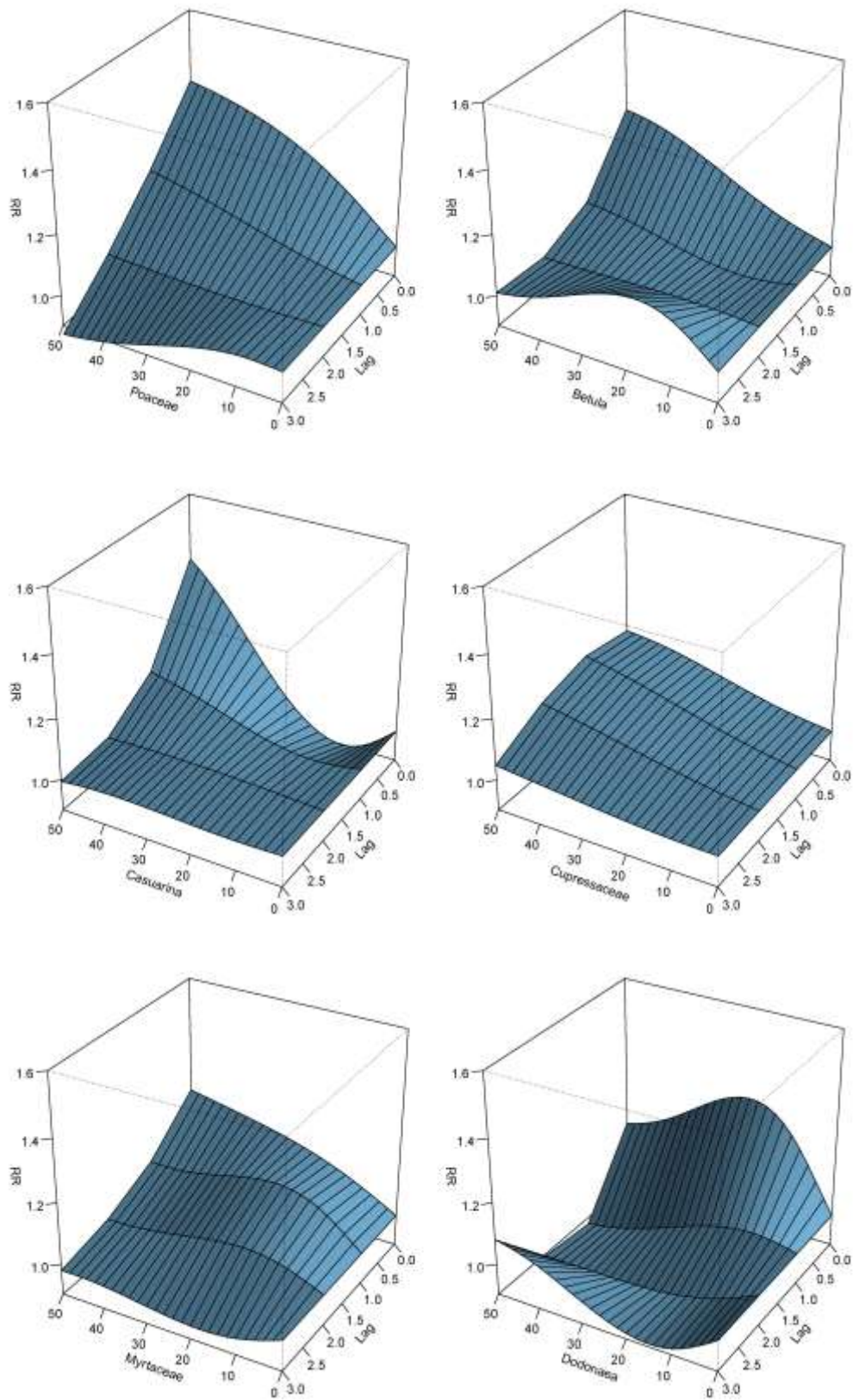


Figure S4: Associations between AirRater app-user reported eye and nose symptoms, and exposure to the pollen taxa *Poaceae*, *Betula*, *Casuarina*, *Cupressaceae*, *Myrtaceae* and *Dodonaea*, in Tasmania, Australia. Associations are represented as relative risk ratios (RR) and Each panel uses a bi-dimensional risk surface to show the response of eye and nose symptoms to a given pollen type over a lag of 0-3 days.

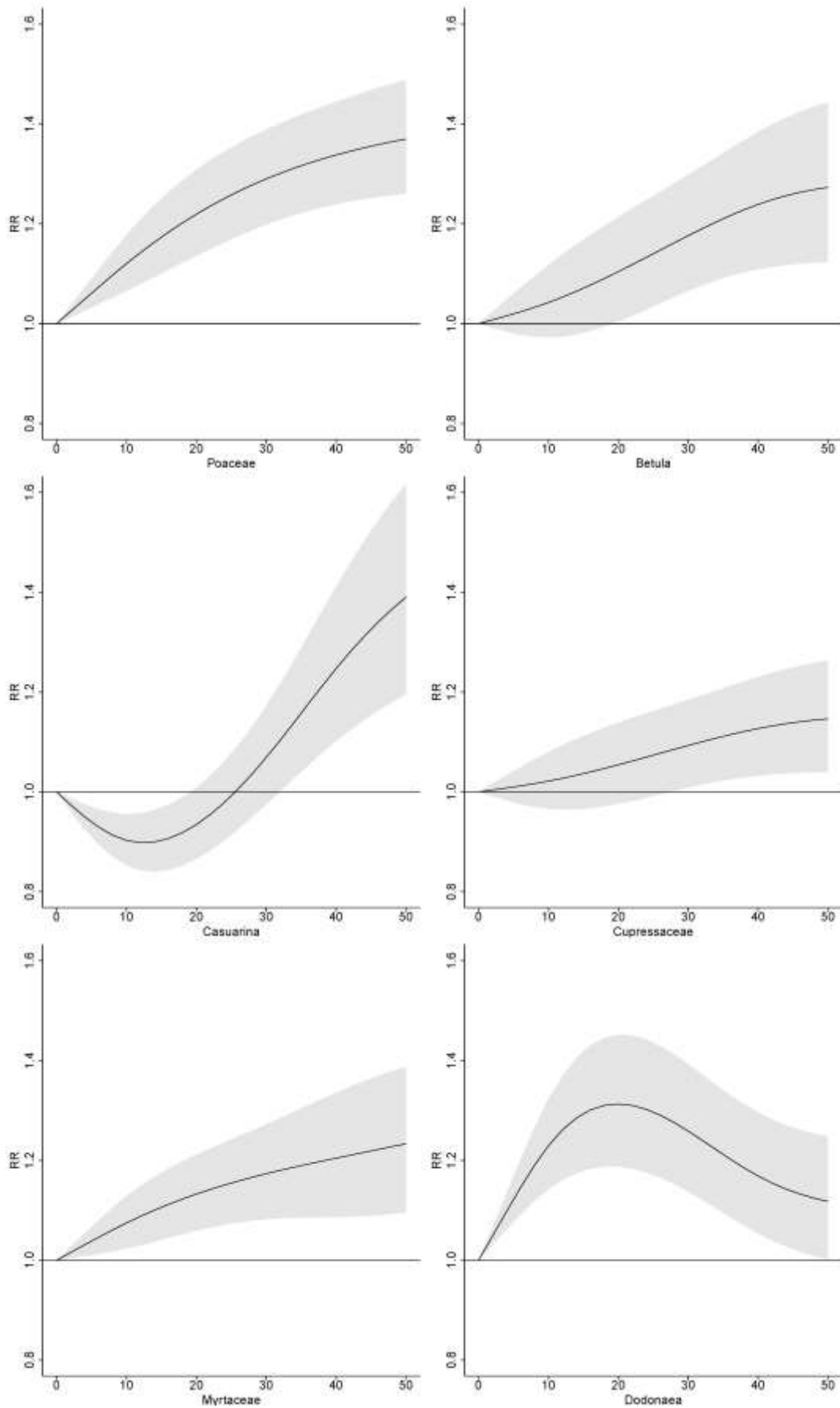


Figure S5: Same-day associations between individual pollen taxa and eye/nose symptoms. Associations are presented as the Risk Ratio (RR) and the grey shading shows the 95% confidence interval.

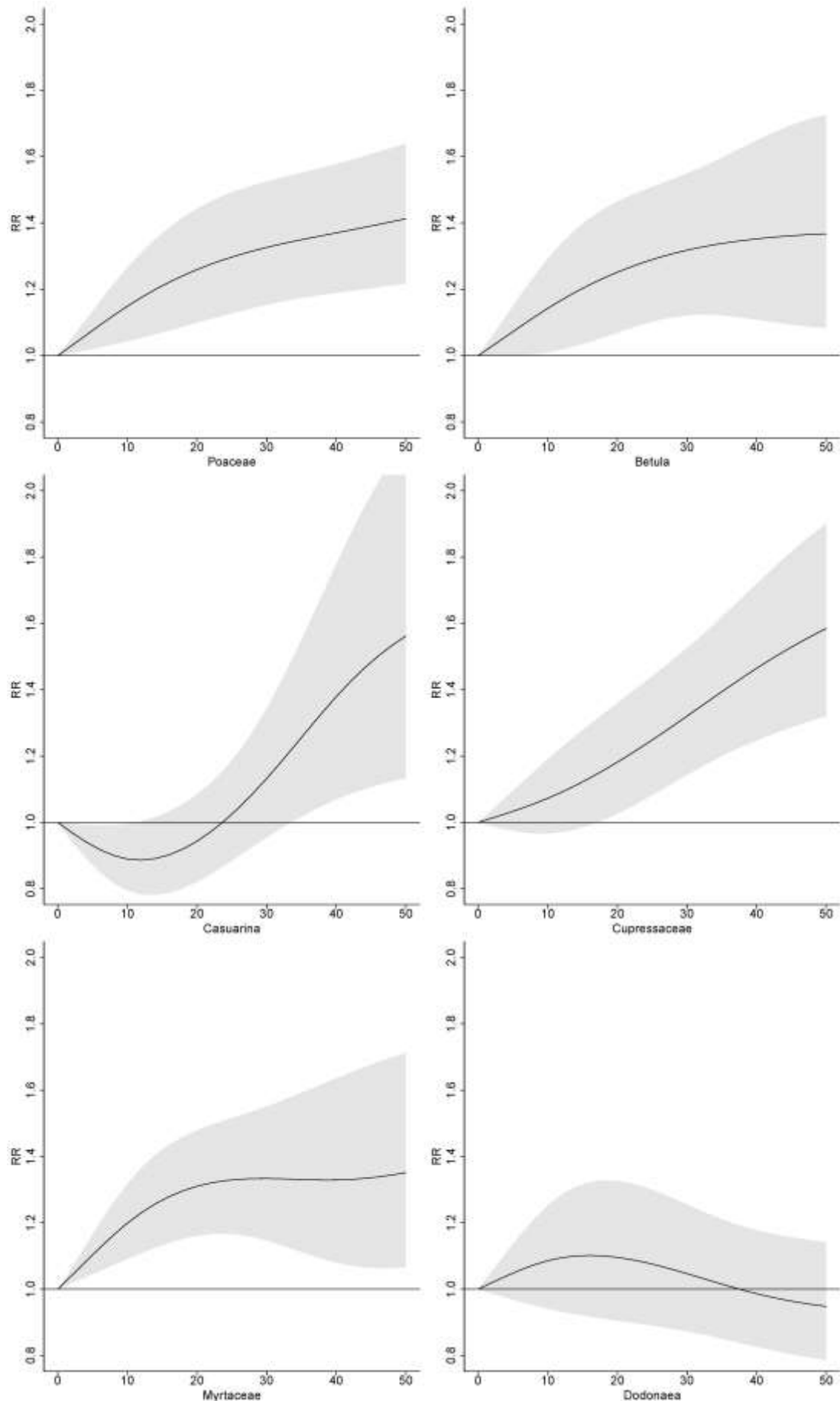


Figure S6: Cumulative three-day associations between individual pollen taxa and eye and nose symptoms. Associations are presented as the Risk Ratio (RR) and the grey shading shows the 95% confidence interval.

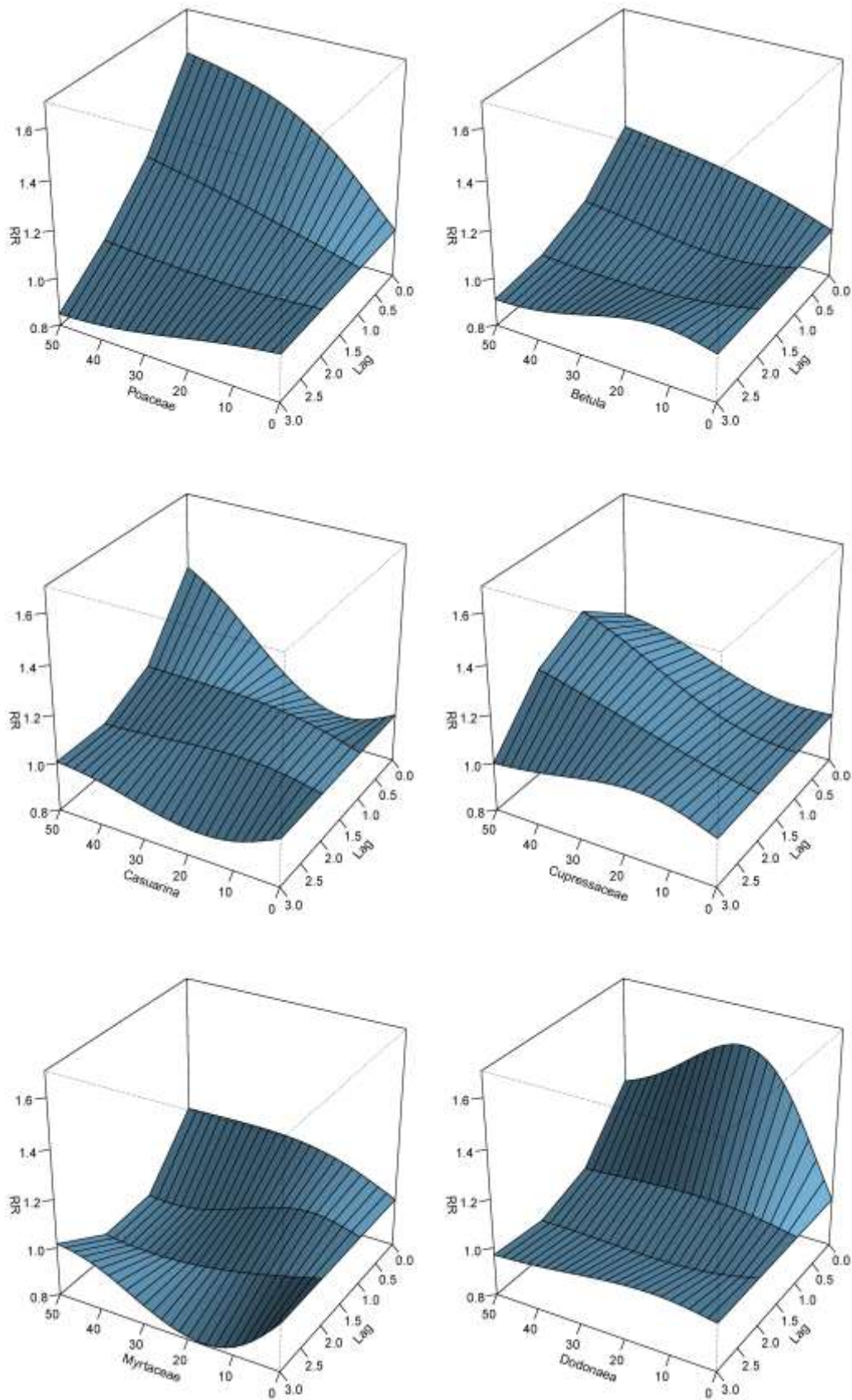


Figure S7: Associations between AirRater app-user reported lung symptoms, and exposure to the pollen taxa *Poaceae*, *Betula*, *Casuarina*, *Cupressaceae*, *Myrtaceae* and *Dodonaea*, in Tasmania, Australia. Associations are represented as relative risk ratios (RR) and Each panel uses a bi-dimensional risk surface to show the response of eye and nose symptoms to a given pollen type over a lag of 0-3 days.

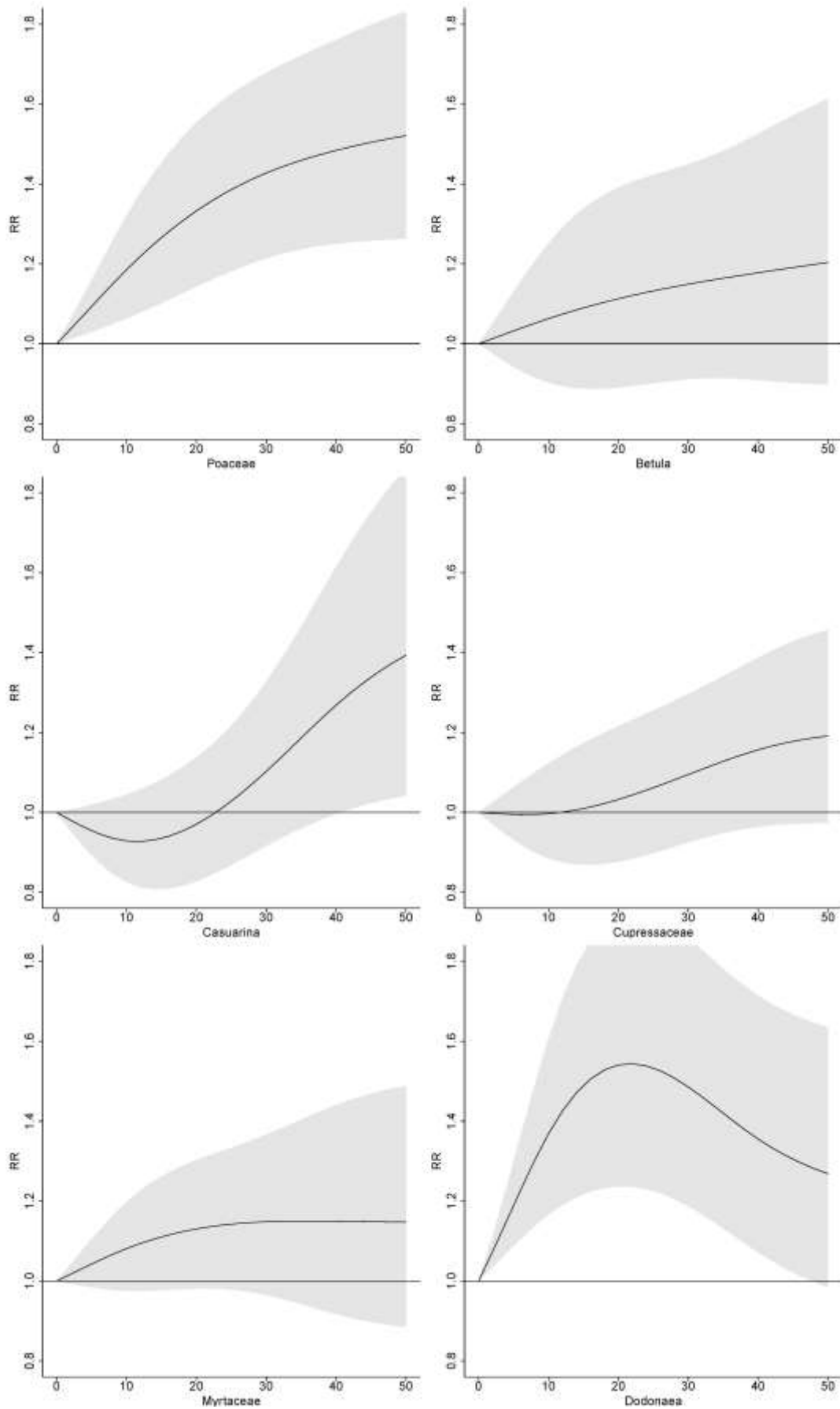


Figure S8: Same-day associations between individual pollen taxa and lung symptoms. Associations are presented as the Risk Ratio (RR) and the grey shading shows the 95% confidence interval.

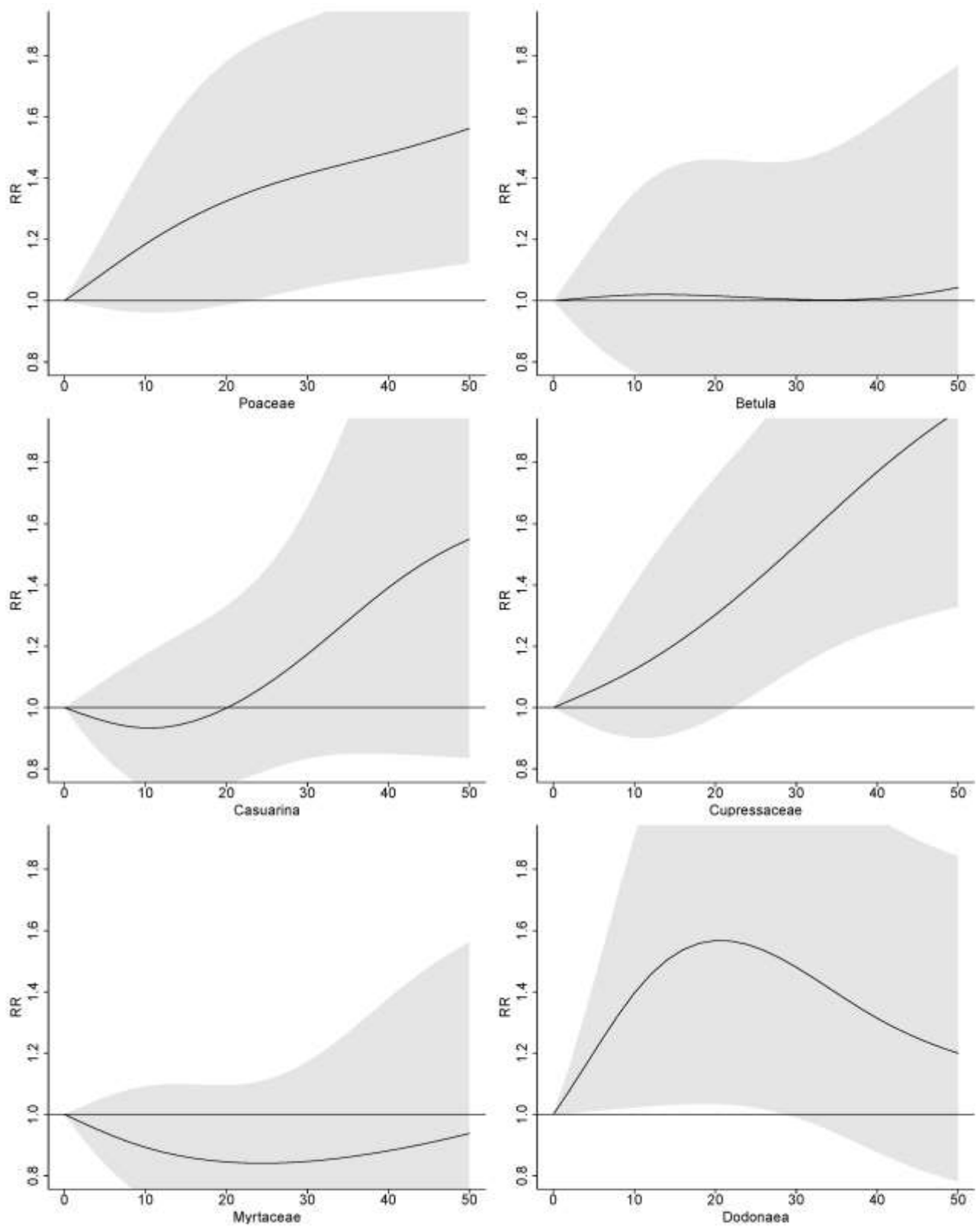


Figure S9: Cumulative three-day associations between individual pollen taxa and lung symptoms. Associations are presented as the Risk Ratio (RR) and the grey shading shows the 95% confidence interval.

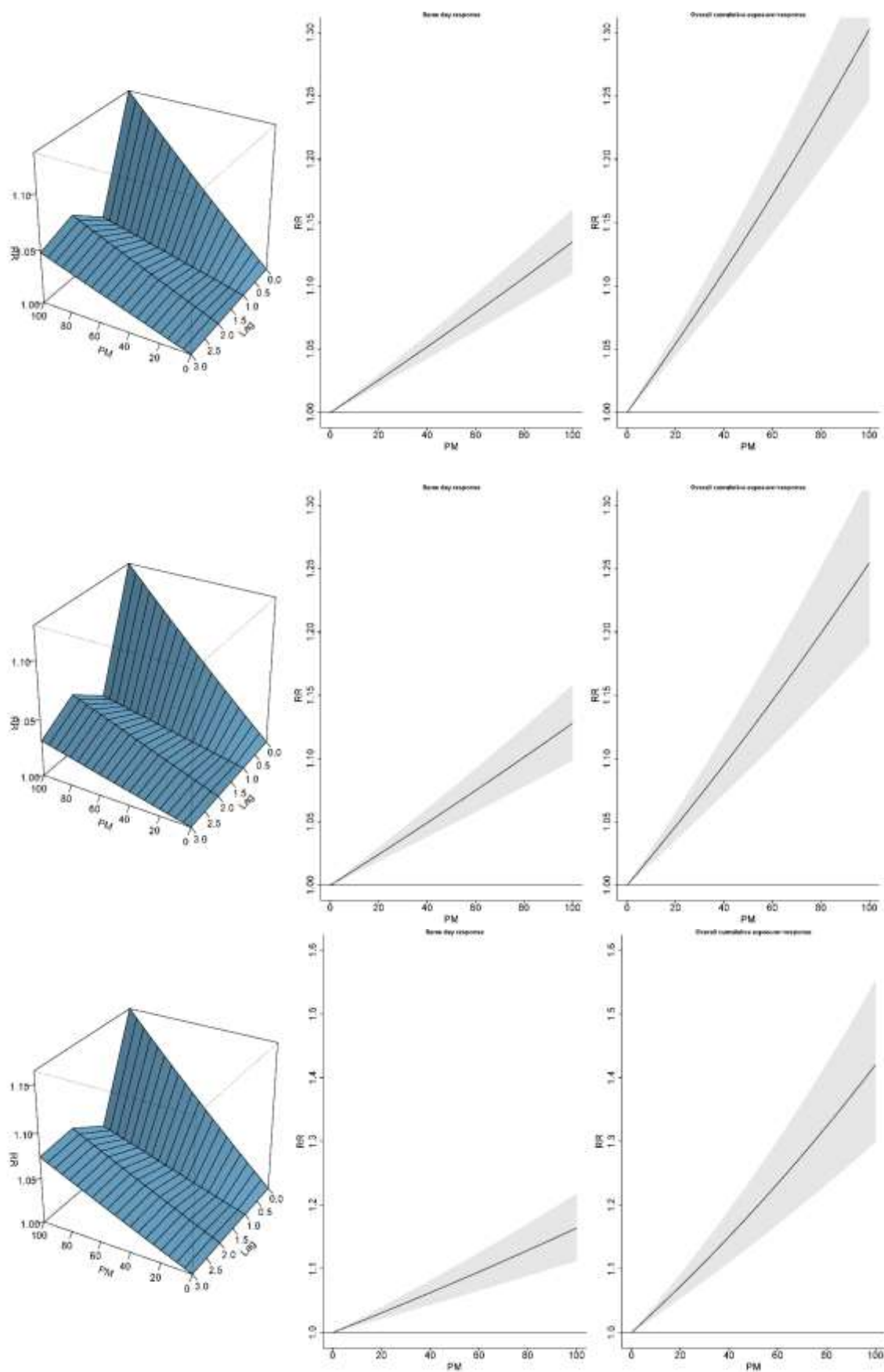


Figure S10: Associations between fine particulate matter ($PM_{2.5}$, $\mu\text{g}/\text{m}^3$) and eye, nose and lung symptoms combined (top), eye/nose symptoms only (middle) and lung symptoms only (bottom) over lag periods of 0-3 days. The left panel shows the full exposure-lag-response as a bidimensional risk surface; the middle panel shows the same-day response (left), and the right panel shows the cumulative three-day response. In all cases associations are represented as Risk Ratios (RR).

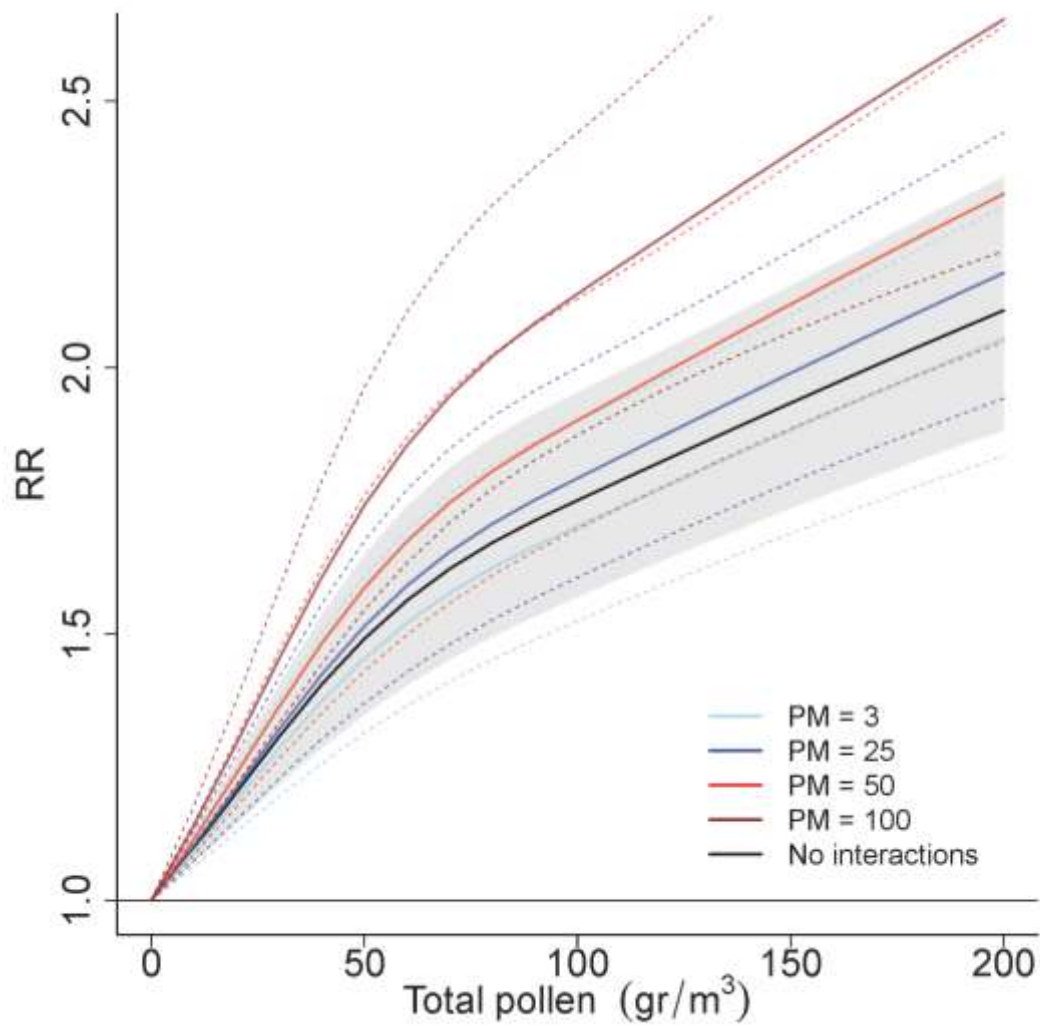


Figure S11: The effect of interactions with selected levels fine particulate matter ($\text{PM}_{2.5}$) on the association between total pollen concentration and AirRater app-user reported eye and nose symptoms. The association between total pollen and symptoms is expressed as the relative risk ratio (RR) and $\text{PM}_{2.5}$ values are in $\mu\text{g}/\text{m}^3$. Grey shading shows the 95% confidence interval for the association with total pollen without a $\text{PM}_{2.5}$ interaction.

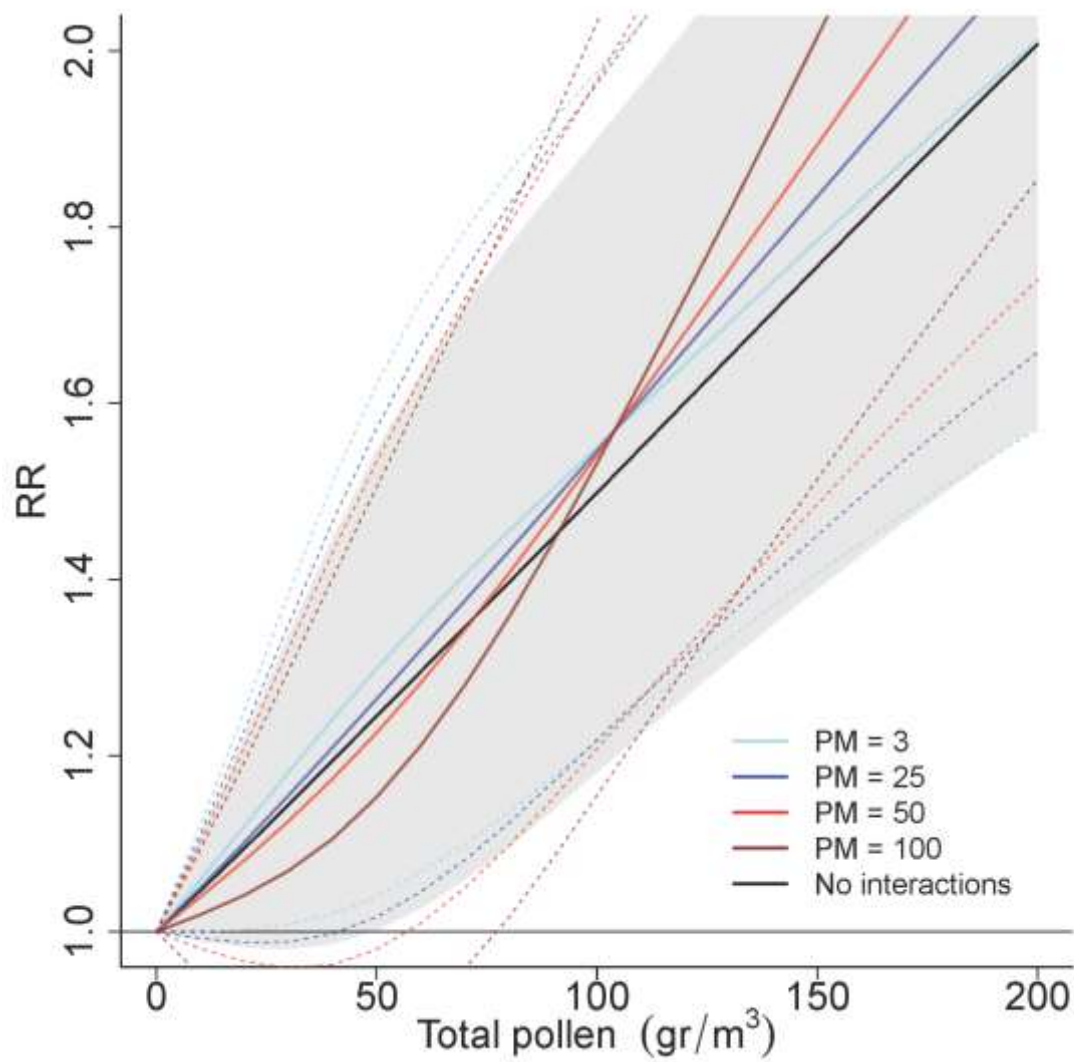


Figure S12: The effect of interactions with selected levels fine particulate matter ($\text{PM}_{2.5}$) on the association between total pollen concentration and AirRater app-user reported lung symptoms. The association between total pollen and symptoms is expressed as the relative risk ratio (RR) and $\text{PM}_{2.5}$ values are in $\mu\text{g}/\text{m}^3$. Grey shading shows the 95% confidence interval for the association with total pollen without a $\text{PM}_{2.5}$ interaction.