Intermediate-term gaseous air pollution exposure and depression in middle-aged and elderly adults: Evidence from a nationwide Chinese cohort

Supplementary appendix

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		١	NO ₂		15	SO ₂			00		(03
Subgroup		β (95% CI)	P-interaction		β (95% CI)	P-interaction		β (95% CI)	P-interaction		β (95% CI)	P-interaction
All	⊢ ∎→1	0.34 (0.02,0.67)		; +++++	0.75 (0.52,0.99)		; +	1.28 (0.44,2.13)		⊢ ∎→;	-0.10 (-0.17,-0.02)	
Gender			0.005			0.520			0.024			0.002
Male	÷	0.40 (-0.03,0.84)			0.74 (0.42,1.07)			1.54 (0.36,2.71)			-0.08 (-0.18,0.02)	
Female	P	0.30 (-0.18,0.78)			0.77 (0.43,1.11)			1.18 (-0.04,2.40)			-0.08 (-0.19,0.03)	
Age			0.465			0.729			0.296			0.0282
≤65		0.36 (-0.03,0.74)			0.73 (0.46,1.01)		·	0.80 (-0.19,1.80)			-0.11 (-0.20,-0.02)	
>65		0.31 (-0.32,0.94)		——	1.01 (0.52,1.50)			2.66 (0.90,4.43)			-0.01 (-0.15,0.14)	
Smoking status			0.526			0.343			0.861			0.184
Yes	⊢	-0.01 (-0.62,0.60)			0.72 (0.25,1.19)			0.64 (-1.03,2.32)			-0.08 (-0.22,0.06)	
No	·	0.48 (0.09,0.86)			0.82 (0.54,1.09)			1.66 (0.67,2.66)			-0.11 (-0.20,-0.02)	
Drinking status			0.001			0.01			0.037			0.343
Yes		0.56 (0.05,1.07)		→	1.04 (0.64,1.43)			1.64 (0.22,3.07)		→ →	-0.11 (-0.23,0.01)	
No	H	0.20 (-0.23,0.63)			0.58 (0.28,0.88)			0.97 (-0.11,2.05)		H	-0.05 (-0.15,0.05)	
Chronic disease			<0.001			0.813			<0.001			< 0.001
Yes	÷	0.40 (-0.04,0.85)			0.60 (0.30,0.90)			0.95 (-0.15,2.05)			-0.05 (-0.16,0.05)	
No		0.56 (-0.03,1.15)			- 1.75 (1.28,2.23)		· · · · · · · · · · · · · · · · · · ·	→ 3.33 (1.64,5.03)			-0.12 (-0.26,0.01)	
Residence			< 0.001			0.904			<0.001			< 0.001
Urban	H	0.35 (-0.14,0.83)		⊢ ••−•	1.05 (0.67,1.42)			1.33 (0.03,2.64)			-0.21 (-0.34,-0.09)	
Rural		0.37 (-0.07,0.81)			0.57 (0.26,0.87)			1.09 (-0.03,2.21)			-0.05 (-0.15,0.05)	
Education level			< 0.001			0.594			<0.001			< 0.001
Primary school or below	→	0.28 (-0.16,0.73)			0.37 (0.05,0.70)		⊢∔ ∎—	0.73 (-0.45,1.91)		⊢	-0.00 (-0.11,0.10)	
Middle school or above		0.48 (0.02,0.94)			1.34 (1.01,1.67)			2.24 (1.05,3.42)			-0.23 (-0.33,-0.12)	
Marital status			<0.001			0.723			< 0.001			<0.001
Married	⊢ ∎→	0.46 (0.11,0.81)		⊢ ∎→	0.88 (0.63,1.13)		·	1.58 (0.68,2.49)			-0.10 (-0.19,-0.02)	
Unmarried +		-0.31 (-1.24,0.62)	-		0.15 (-0.51,0.81)	⊢	·	-0.16 (-2.61,2.30)			→ 0.05 (-0.18,0.27)	
Physical activity			0.163			0.396			0.501			0.124
Highly		0.52 (-0.09,1.12)			0.72 (0.30,1.14)			1.22 (-0.37,2.80)			-0.07 (-0.21,0.06)	
Moderate	⊢ ;∎→	0.19 (-0.38,0.77)			1.19 (0.76,1.61)			1.90 (0.40,3.40)	H		-0.24 (-0.37,-0.11)	
Mild		-0.05 (-0.65,0.55)			0.55 (0.10,1.01)			0.22 (-1.38,1.81)		·	0.08 (-0.06,0.22)	
Fuel type			0.133			0.389			0.582			0.100
Clean fuel		0.03 (-0.37,0.44)		— —	0.97 (0.65,1.29)			0.87 (-0.23,1.98)			-0.11 (-0.21,-0.02)	
Solid fuel		1.33 (0.65,2.01)			0.85 (0.43,1.27)		· · · · · · · · · · · · · · · · · · ·	2.79 (1.19,4.39)		⊢ ∎→	-0.14 (-0.29,0.00)	
	-1 -0.5 0 0.5 1 1	5 2	-0.5	0 0.5 1 1.5	2		-2 0 2 4			-0.3 -0.2 -0.1 0 0.1 0.2	2	
	β (95% CI)		β (9	95% CI)			β (95% CI)			β (95% CI)		

Figure S1. The association between gaseous air pollutants and depression scores in different subgroups at 60 lag days. The associations were estimated using model 4.

Abbreviations: CI, confidence interval; NO₂, nitrogen dioxide; SO₂, sulfur dioxide; CO, carbon monoxide; O₃, ozone.

		1	NO ₂			SO ₂		С	0			O ₃
Subgroup		β (95% CT)	P-interaction		β (95% CI)	P-interaction		β (95% CI)	P-interaction		β (95% CI)	P-interaction
All	► <u></u>	0.15 (-0.20,0.50)		;	0.74 (0.52,0.97)		; 	1.01 (0.13,1.89)			-0.20 (-0.29,-0.10)	
Gender			<0.001			0.451			0.008			0.010
Male		0.21 (-0.26,0.67)			0.73 (0.41,1.05)			1.02 (-0.20,2.24)		→	-0.16 (-0.28,-0.04)	
Female		0.14 (-0.37,0.65)			0.77 (0.44,1.09)			1.10 (-0.16,2.37)			-0.18 (-0.31,-0.05)	
Age	1		0.016			0.745			0.179			0.076
≤65		0.18 (-0.23,0.60)			0.73 (0.47,1.00)			0.44 (-0.60,1.47)			-0.21 (-0.31,-0.10)	
>65		0.02 (-0.64,0.69)			→ 0.96 (0.48,1.43)			→ 2.48 (0.66,4.31)			-0.09 (-0.27,0.09)	
Smoking status			0.407			0.296			0.687			0.284
Yes	·•	-0.29 (-0.95,0.37)			0.67 (0.21,1.13)	<		-0.02 (-1.76,1.71)			-0.16 (-0.32,0.01)	
No	+	0.32 (-0.10,0.73)			0.82 (0.56,1.09)			1.53 (0.50,2.57)		• • • • • • • • • • • • • • • • • • •	-0.22 (-0.33,-0.11)	
Drinking status			0.010			0.005			0.0467			0.330
Yes		0.36 (-0.19,0.91)			→ 1.02 (0.64,1.39)			1.30 (-0.18,2.77)		· · · · ·	-0.21 (-0.35,-0.07)	
No		0.02 (-0.44,0.47)			0.57 (0.28,0.87)		·	0.71 (-0.41,1.83)		·•	-0.13 (-0.24,-0.01)	
Chronic disease			<0.001			0.867			<0.001			<0.001
Yes	⊢	0.23 (-0.25,0.72)		; 	0.59 (0.29,0.88)		⊢ ;	0.77 (-0.38,1.92)			-0.13 (-0.25,-0.01)	
No		0.26 (-0.35,0.88)		+	→ 1.66 (1.21,2.10)			⇒ 2.72 (0.98,4.46)			-0.26 (-0.42,-0.11)	
Residence			< 0.001			0.928			<0.001			<0.001
Urban	· · · · ·	0.04 (-0.48,0.56)			⊣ 1.03 (0.66,1.39)		• • •	0.94 (-0.41,2.29)	•	9 4	-0.37 (-0.53,-0.22)	
Rural		0.27 (-0.20,0.74)		· • • · ·	0.58 (0.29,0.87)			0.89 (-0.27,2.06)		·•	-0.14 (-0.26,-0.02)	
Education level			< 0.001			0.964			<0.001			<0.001
Primary school or below		0.17 (-0.31,0.65)			0.38 (0.06,0.69)			0.58 (-0.65,1.81)			-0.07 (-0.20,0.05)	
Middle school or above	<u>⊢ ; = </u>	0.18 (-0.31,0.67)			\mapsto 1.31 (0.99,1.63)			→ 1.79 (0.56,3.02)		(* 1	-0.37 (-0.49,-0.24)	
Marital status			<0.001			0.253			<0.001			0.004
Married	⊢	0.24 (-0.13,0.61)			0.86 (0.61,1.10)			1.29 (0.34,2.23)		► • • • •	-0.22 (-0.32,-0.13)	
Unmarried	<	-0.37 (-1.37,0.64)	,		0.21 (-0.43,0.85)	+		-0.34 (-2.84,2.17)			→ 0.09 (-0.17,0.35)	
Physical activity			0.064			0.382			0.657			0.253
Highly		0.35 (-0.29,0.99)			0.73 (0.32,1.14)			0.94 (-0.71,2.58)		•••••••	-0.19 (-0.34,-0.03)	
Moderate		-0.08 (-0.70,0.53)			→ 1.18 (0.76,1.59)			→ 1.58 (0.02,3.14)	•	•	-0.38 (-0.54,-0.23)	
Mild		-0.20 (-0.85,0.44)			0.53 (0.10,0.97)	÷		-0.03 (-1.68,1.63)			→ 0.09 (-0.08,0.26)	
Fuel type			0.048			0.335			0.572			0.244
Clean fuel		-0.19 (-0.63,0.24)			0.95 (0.64,1.26)		· · · · · · · · · · · · · · · · · · ·	0.54 (-0.60,1.68)			-0.21 (-0.32,-0.10)	
Solid fuel		→ 1.36 (0.61,2.10)			0.89 (0.48,1.29)			• 2.89 (1.19,4.60)	;		-0.25 (-0.42,-0.08)	
-	1 -0.5 0 0.5 1	1.5	-0.5	0 0.5 1	1.5		-1 0 1 2	3	-0	4 -0.3 -0.2 -0.1 0 0.1	0.2	
	β (95% CI)		β (9	5% CI)			β (95% CI)			β (95% CI)		

Figure S2. The association between gaseous air pollutants and depression scores in different subgroups at 90 lag days. The associations were estimated using model 4.

Abbreviations: CI, confidence interval; NO₂, nitrogen dioxide; SO₂, sulfur dioxide; CO, carbon monoxide; O₃, ozone.

		. 1	NO ₂			SO ₂			20		(D ₃
Subgroup		β (95% CI)	P-interaction		β (95% CI)	P-interaction		β (95% CI)	P-interaction		β (95% CI)	P-interaction
All		-0.38 (-0.70,-0.06)		; 	0.45 (0.27,0.62)		÷ • • •	0.60 (-0.17,1.37)		H	-0.30 (-0.41,-0.20)	
Gender			<0,001			0,105			0.003	i i		0.0117
Male		-0.32 (-0.76,0.11)		⊢ ∎−−1	0.43 (0.18,0.67)			0.22 (-0.85,1.28)		⊢ ∎1	-0.23 (-0.37,-0.10)	
Female		-0.35 (-0.81,0.11)			0.49 (0.24,0.73)		+	1.03 (-0.07,2.13)		÷ -	-0.31 (-0.46,-0.15)	
Age	i.		<0.001	i i		0,776			0.107	i		0.248
≤65		-0.31 (-0.70,0.07)			0.44 (0.24,0.65)			0.06 (-0.84,0.96)		i i i	-0.30 (-0.42,-0.18)	
>65	·	-0.63 (-1.24,-0.02)			⊐ 0.57 (0.20,0.93)			→ 2.06 (0.45,3.66)			-0.26 (-0.46,-0.06)	
Smoking status			<0.001	1		0.522			0.550	i i		0.740
Yes		-0.72 (-1.33,-0.11)			0.30 (-0.05,0.66)			-0.74 (-2.24,0.75)			-0.21 (-0.40,-0.02)	
No		-0.26 (-0.64,0.12)			0,53 (0,32,0,73)			1.18 (0,28,2,09)			-0,34 (-0,46,-0,22)	
Drinking status			0,386			0.003			0.044			0,137
Yes		-0.19 (-0.70,0.32)		· · · · ·	→ 0.66 (0.38,0.94)			0.87 (-0.41,2.15)			-0.34 (-0.50,-0.18)	
No	·	-0.49 (-0.91,-0.07)		·•	0.31 (0.09,0.54)			0.35 (-0.63,1.33)			-0.21 (-0.35,-0.08)	
Chronic disease			<0.001			0.023			<0.001			0.001
Yes		-0.24 (-0.68,0.21)			0,32 (0,10,0,55)			0.39 (-0.64,1.41)			-0.20 (-0.34,-0.06)	
No		-0.58 (-1.16,-0.00)		- ⊢	→ 1.11 (0.77,1.45)			→ 2.19 (0.69,3.69)		← •−−	-0,45 (-0,63,-0,28)	
Residence			<0.001			0.015			<0.001	1		0.001
Urban	, — — — i	-0.58 (-1.07,-0.08)		· · · ·	4 0.62 (0.33,0.90)			0.46 (-0.72,1.64)		← ∎→	-0.49 (-0.67,-0.31)	
Rural		-0.23 (-0.65,0.19)		·•	0.36 (0.14,0.58)			0.60 (-0.40,1.61)			-0.27 (-0.40,-0.14)	
Education level			<0.001	1		0.013	1		<0.001	1		0.001
Primary school or below	•	-0.13 (-0.57,0.32)		i i i i i i i i i i i i i i i i i i i	0.21 (-0.03,0.45)			0.29 (-0.78,1.37)		, — ∎—_j	-0.14 (-0.28,0.00)	
Middle school or above		-0.69 (-1.13,-0.24)			→ 0.80 (0.56,1.04)			1.17 (0.11,2.23)		← ■→	-0.53 (-0.68,-0.38)	
Marital status			<0.001			0.945	1		<0.001	1		0.086
Married	·	-0.31 (-0.65,0.03)			0.52 (0.34,0.71)		÷	0.76 (-0.07,1.58)		i	-0.32 (-0.43,-0.21)	
Unmarried	<	-0.76 (-1.70,0.19)			0.06 (-0.42,0.55)		· · · · · · · · · · · · · · · · · · ·	-0.22 (-2.38,1.95)			-0.11 (-0.41,0.18)	
Physical activity			0.009	-		0.954			0.173	1		0.263
Highly	·	-0.09 (-0.66,0,49)			0,50 (0,18,0,81)			0.94 (-0,49,2.38)			-0.27 (-0.45,-0.09)	
Moderate		-0.78 (-1.35,-0.21)			→ 0.71 (0.40,1.03)			0.96 (-0.40,2.33)		→ → →	-0.51 (-0.69,-0.33)	
Mild		-0.48 (-1.08,0,12)		+	0.27 (-0.06,0.61)	•		-0,33 (-1,78,1,11)			→ 0.01 (-0.18,0.20)	
Fuel type			0.004			0.849			0.132			0.323
Clean fuel		-0.76 (-1.16,-0.36)		· · · · · ·	0.55 (0.32,0.79)			0.22 (-0.77,1.21)		i	-0.33 (-0.47,-0.20)	
Solid fuel		→ 0.77 (0.09,1.45)			- 0.66 (0.34,0.98)			→ 2.60 (1.06,4.14)			-0.35 (-0.54,-0.16)	
-1	.5 -1 0	0.5 1	-0.5	0 0.5	1		-1 0 1 2	3	-0	.6 -0.4 -0.2 0	0.2	
	β (95%	i CI)	β	(95% Cl)			β (95% CI)			β (95% C	21)	

Figure S3. The association between gaseous air pollutants and depression scores in different subgroups at 180 lag days. The associations were estimated using model 4.

Abbreviations: CI, confidence interval; NO₂, nitrogen dioxide; SO₂, sulfur dioxide; CO, carbon monoxide; O₃, ozone.



Figure S4. The dose-response curve of gaseous air pollutants (NO₂, SO₂, CO, and O₃) and depression scores.

Abbreviations: NO₂, nitrogen dioxide; SO₂, sulfur dioxide; CO, carbon monoxide; O₃, ozone.

	Wave2013	Wave2015	Wave2018
Wave2015	0.58 (0.56, 0.59)		
Wave2018	0.51 (0.48, 0.52)	0.57 (0.55, 0.59)	
Wave2020	0.52 (0.50, 0.54)	0.56 (0.54, 0.58)	0.61 (0.59, 0.62)

Table S1. Intraclass correlation coefficients (ICC) for depression score during four waves (2013, 2015, 2018, and 2020).

Results present as ICC (95% CI).

CI: confidence interval.

Variables	VIF
NO ₂	2.66
SO ₂	2.16
СО	2.94
O ₃	2.92
City	1.02
Gender	1.31
Age	1.15
Residence	1.36
Education level	1.14
Marital status	1.06
Smoking status	1.20
Drinking status	1.14
Chronic disease	1.05
Physical activity	1.07
Cooking fuel	1.08

Table S2. Variance inflation factor (VIF) of variables included in the multivariableadjusted model.

	Model 1	Model 2	Model 3	Model 4
NO ₂				
30-days	0.42 (0.24, 0.60) ***	0.43 (0.25, 0.61) ***	0.46 (0.21, 0.72) ***	0.55 (0.25, 0.85) ***
60-days	0.37 (0.16, 0.57) ***	0.37 (0.17, 0.58) ***	0.31 (0.02, 0.60) *	0.34 (0.02, 0.67) *
90-days	0.26 (0.04, 0.49) *	0.27 (0.04, 0.50) *	0.15 (-0.16, 0.46)	0.15 (-0.20, 0.50)
180-days	-0.14 (-0.35, 0.06)	-0.14 (-0.34, 0.06)	-0.26 (-0.55, 0.02)	-0.38 (-0.70, -0.06) *
SO ₂				
30-days	0.43 (0.31, 0.55) ***	0.43 (0.31, 0.55) ***	0.48 (0.30, 0.67) ***	0.68 (0.45, 0.90) ***
60-days	0.53 (0.40, 0.66) ***	0.53 (0.40, 0.66) ***	0.57 (0.37, 0.76) ***	0.75 (0.52, 0.99) ***
90-days	0.54 (0.41, 0.66) ***	0.54 (0.42, 0.66) ***	0.57 (0.38, 0.76) ***	0.74 (0.52, 0.97) ***
180-days	0.34 (0.25, 0.43) ***	0.34 (0.25, 0.43) ***	0.34 (0.20, 0.49) ***	0.45 (0.27, 0.62) ***
CO				
30-days	0.58 (0.16, 1.01) **	0.61 (0.18, 1.03) **	0.96 (0.30, 1.62) **	1.19 (0.39, 1.99) **
60-days	0.68 (0.23, 1.13) **	0.71 (0.26, 1.16) **	1.04 (0.34, 1.74) **	1.28 (0.44, 2.13) **
90-days	0.56 (0.09, 1.03) *	0.59 (0.12, 1.06) *	0.83 (0.10, 1.55) *	1.01 (0.13, 1.89) *
180-days	0.50 (0.09, 0.91) *	0.52 (0.11, 0.93) *	0.47 (-0.16, 1.11)	0.60 (-0.17, 1.37)
O ₃				
30-days	0.04 (-0.01, 0.09)	-0.10 (-0.15, -0.05) ***	-0.18 (-0.23, -0.12) ***	-0.27 (-0.34, -0.21) ***
60-days	0.05 (-0.00, 0.10)	-0.10 (-0.14, -0.05) ***	-0.17 (-0.22, -0.12) ***	-0.27 (-0.33, -0.21) ***
90-days	0.08 (0.01, 0.15) *	-0.06 (-0.12, 0.01)	-0.13 (-0.21, -0.06) ***	-0.22 (-0.30, -0.13)
180-days	0.06 (-0.02, 0.14)	-0.09 (-0.17, -0.02) *	-0.19 (-0.28, -0.10) ***	-0.30 (-0.41, -0.20) ***

Table S3. Associations of different time-window ambient gaseous air pollutants (NO₂, SO₂, CO, and O₃) exposure with depression score.

Model 1 was crude model.

Model 2 was adjusted for age, sex, educational level, marital status and residence on the basis of model 1.

Model 3 was adjusted for alcohol drinking, cigarette smoking, physical activity and chronic diseases on the basis of model 2.

Model 4 was adjusted for household cooking fuel and outdoor temperature on the basis of model 3.

Abbreviations: NO₂, nitrogen dioxide; SO₂, sulfur dioxide; CO, carbon dioxide; O₃, ozone.

* P < 0.05; ** P < 0.01; *** P < 0.001.

	Model 1	Model 2	Model 3	Model 4
NO ₂				
30-days	0.42 (0.24, 0.60) ***	0.43 (0.25, 0.61) ***	0.44 (0.26, 0.61) ***	0.43 (0.26, 0.61) ***
60-days	0.37 (0.16, 0.57) ***	0.37 (0.16, 0.58) ***	0.35 (0.15, 0.56) ***	0.35 (0.14, 0.55) ***
90-days	0.26 (0.04, 0.49) *	0.27 (0.04, 0.50) *	0.23 (0.00, 0.45) *	0.22 (-0.01, 0.45)
180-days	-0.14 (-0.35, 0.06)	-0.14 (-0.34, 0.06)	-0.22 (-0.43, -0.02) *	-0.23 (-0.44, -0.03) *
SO ₂				
30-days	0.43 (0.31, 0.55) ***	0.43 (0.31, 0.55) ***	0.47 (0.35, 0.59) ***	0.48 (0.36, 0.60) ***
60-days	0.53 (0.40, 0.66) ***	0.53 (0.40, 0.66) ***	0.58 (0.45, 0.71) ***	0.59 (0.46, 0.71) ***
90-days	0.54 (0.41, 0.66) ***	0.54 (0.41, 0.66) ***	0.59 (0.47, 0.71) ***	0.59 (0.47, 0.71) ***
180-days	0.34 (0.25, 0.43) ***	0.34 (0.25, 0.43) ***	0.37 (0.28, 0.46) ***	0.37 (0.28, 0.46) ***
CO				
30-days	0.58 (0.16, 1.01) **	0.61 (0.18, 1.03) **	0.67 (0.25, 1.09) **	0.68 (0.26, 1.10) **
60-days	0.68 (0.23, 1.13) **	0.71 (0.25, 1.16) **	0.77 (0.32, 1.23) ***	0.79 (0.33, 1.24) ***
90-days	0.56 (0.09, 1.03) *	0.58 (0.11, 1.05) *	0.65 (0.18, 1.12) **	0.65 (0.18, 1.13) **
180-days	0.50 (0.09, 0.91) *	0.52 (0.11, 0.93) *	0.55 (0.14, 0.97) **	0.56 (0.14, 0.97) **
O ₃				
30-days	0.04 (-0.01, 0.09)	0.05 (-0.00, 0.10)	0.04 (-0.01, 0.09)	0.04 (-0.01, 0.09)
60-days	-0.10 (-0.15, -0.05) ***	-0.10 (-0.14, -0.05) ***	-0.12 (-0.16, -0.07) ***	-0.12 (-0.16, -0.07) ***
90-days	-0.18 (-0.23, -0.12) ***	-0.17 (-0.22, -0.12) ***	-0.20 (-0.25, -0.14) ***	-0.20 (-0.25, -0.14) ***
180-days	-0.27 (-0.34, -0.21) ***	-0.27 (-0.33, -0.21) ***	-0.30 (-0.37, -0.24) ***	-0.30 (-0.37, -0.24) ***

Table S4. Associations of different time-window gaseous air pollutants (NO₂, SO₂, CO, and O₃) exposure with depression score using multiple imputation approach.

Model 1 was crude model.

Model 2 was adjusted for age, sex, educational level, marital status and residence on the basis of model 1.

Model 3 was adjusted for alcohol drinking, cigarette smoking, physical activity and chronic diseases on the basis of model 2.

Model 4 was adjusted for household cooking fuel and outdoor temperature on the basis of model 3.

Abbreviations: NO₂, nitrogen dioxide; SO₂, sulfur dioxide; CO, carbon dioxide; O₃, ozone.

* *P* < 0.05; ** *P* < 0.01; *** *P* < 0.001.