Supplementary Materials: Health Burden and Driving Force Changes Due to Exposure to $PM_{2.5}$ and O_3 from 2014 to 2060 in a Typical Industrial Province, China

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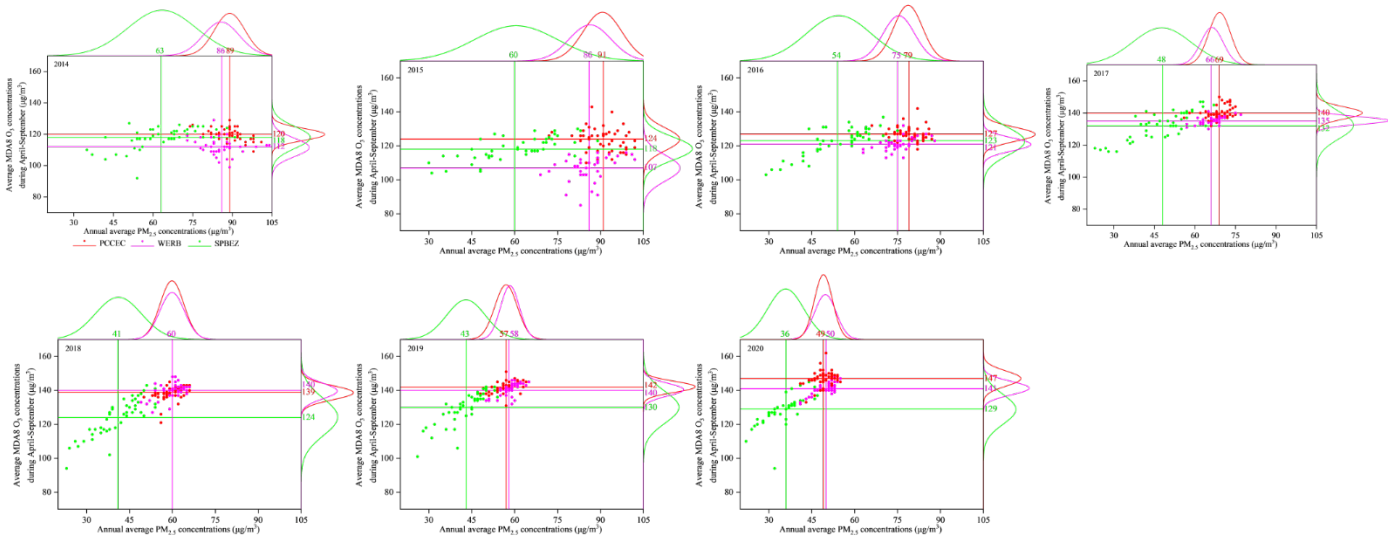

Figure S1. Annual April–September average MDA8 O_3 concentrations and annual average $PM_{2.5}$ concentrations for each district and county in PCCEC, WERB, and SPBEZ from 2014 to 2020.

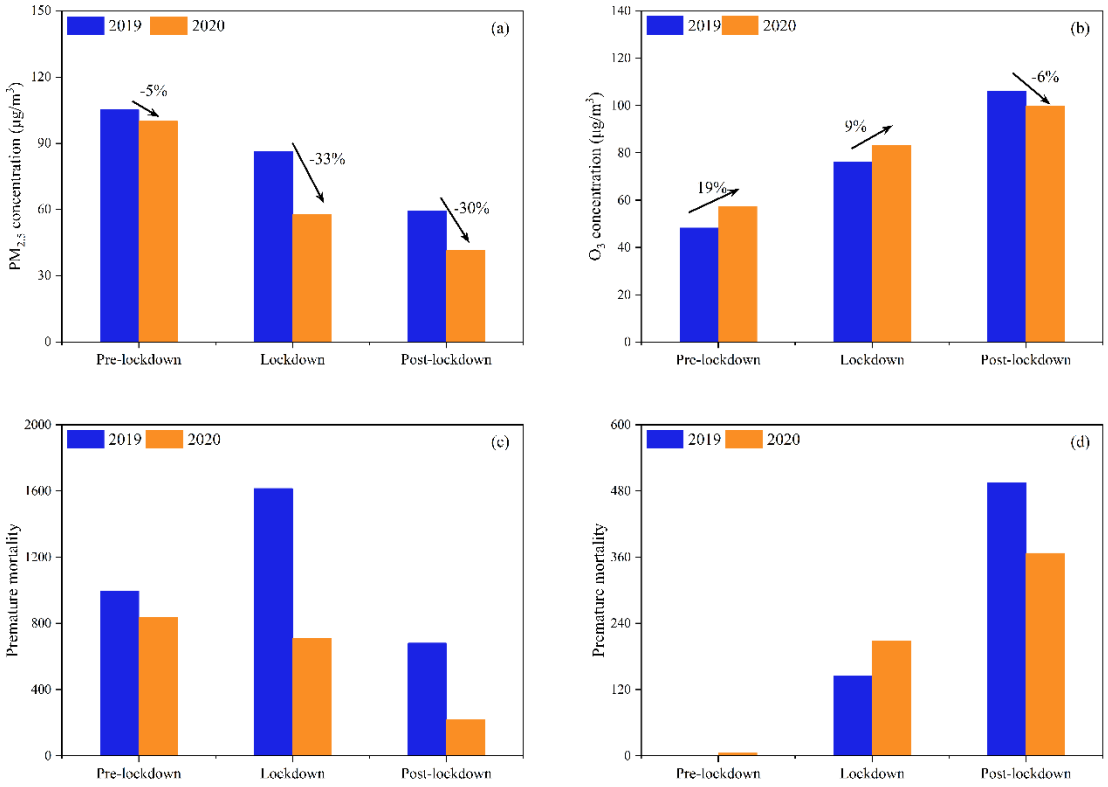

Figure S2. Comparative analysis of $PM_{2.5}$ (a) and O_3 (b) concentration variations in Shandong province during the Pre-lockdown (Jan. 6–Jan. 22), Lockdown (Jan. 23–Feb. 28), and Post-lockdown (Mar. 1–Mar. 31) periods in 2019 and 2020, along with the associated premature deaths due to short-term exposure to $PM_{2.5}$ (c) and O_3 (d).

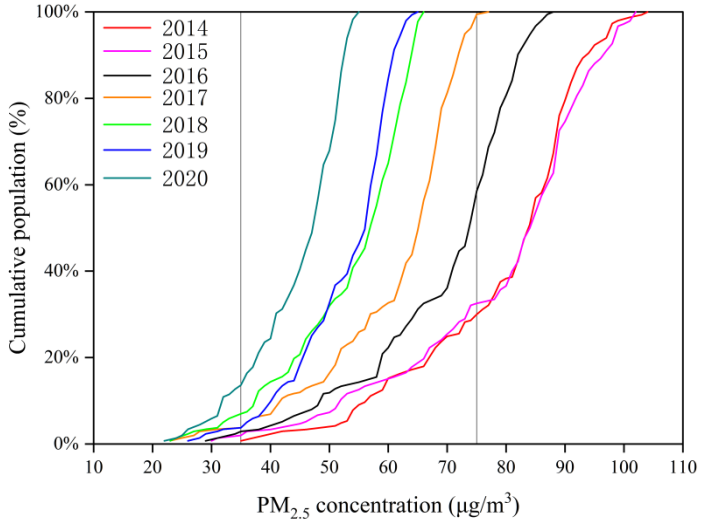

Figure S3. Cumulative distribution of population living under different ambient $PM_{2.5}$ concentrations in Shandong province from 2014 to 2020.

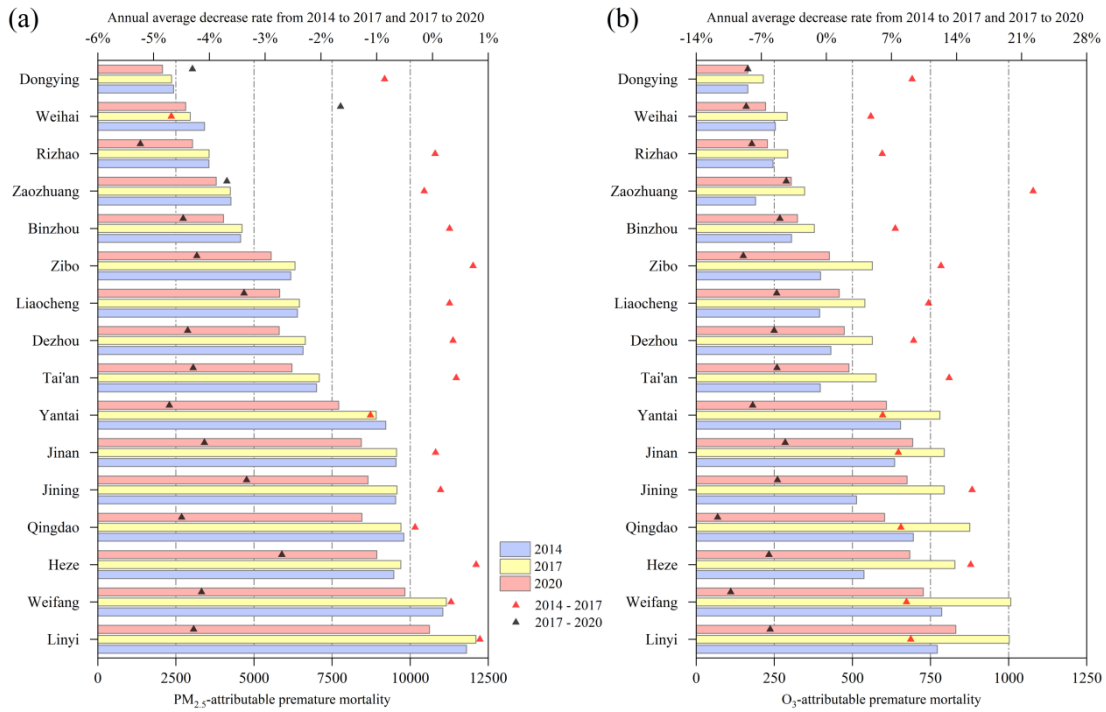

Figure S4. Temporal variations in premature mortality due to long-term exposure to $PM_{2.5}$ (a) and O_3 (b) in Shandong province at the city level from 2014 to 2020.

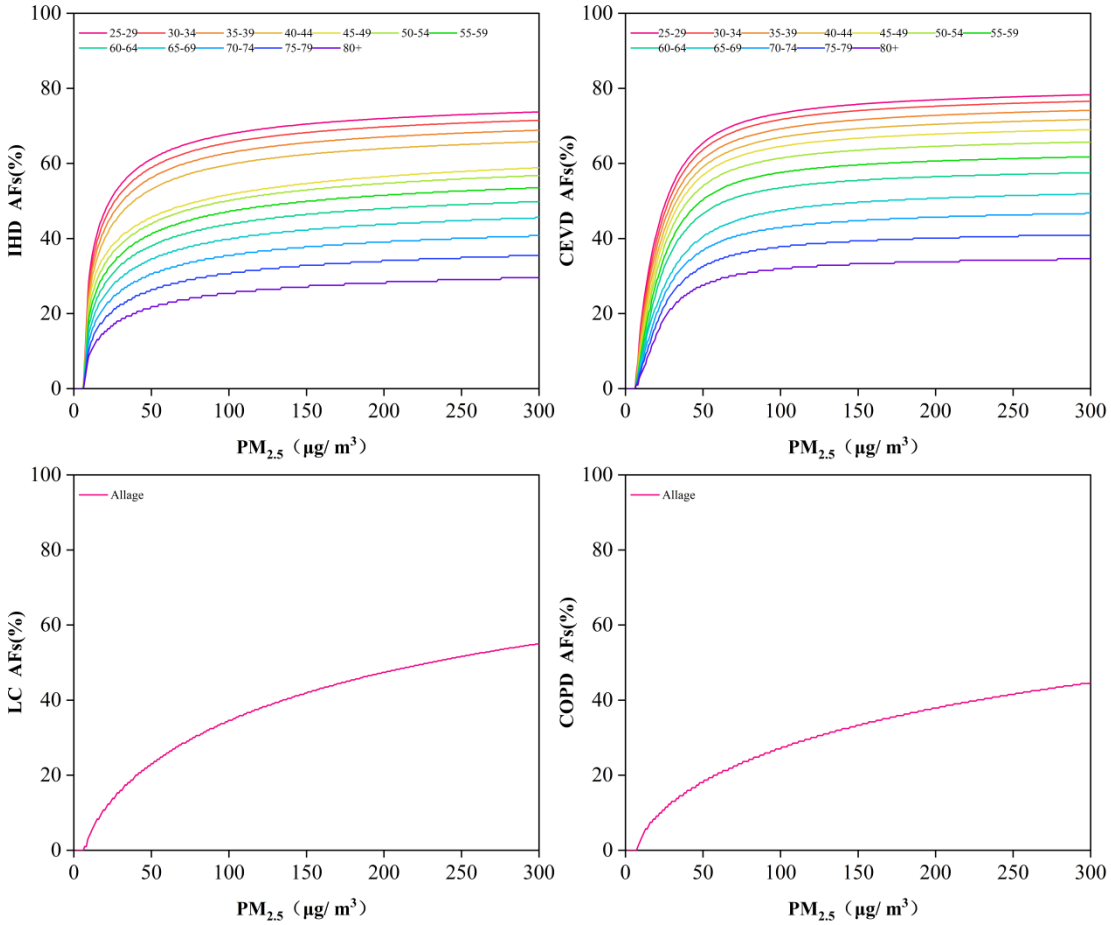

Figure S5. The set of AF change curves for each health endpoint at corresponding $PM_{2.5}$ concentrations.

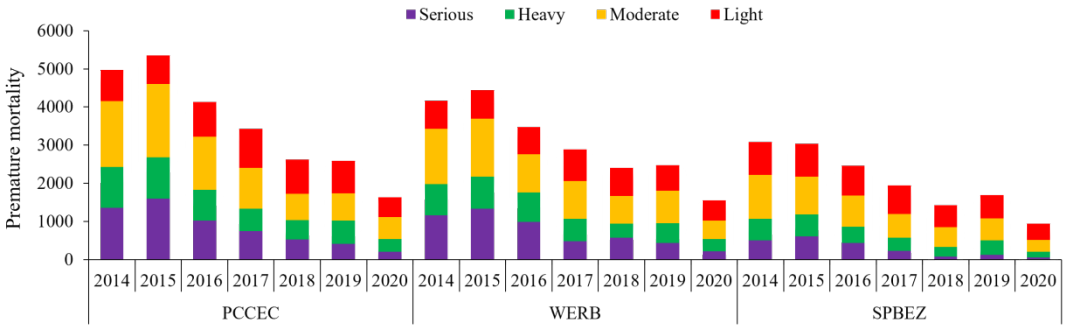

Figure S6. Premature mortality associated with short-term exposure to $PM_{2.5}$ in different pollution levels in PCEEC, WERB, and SPBEZ from 2014 to 2020.

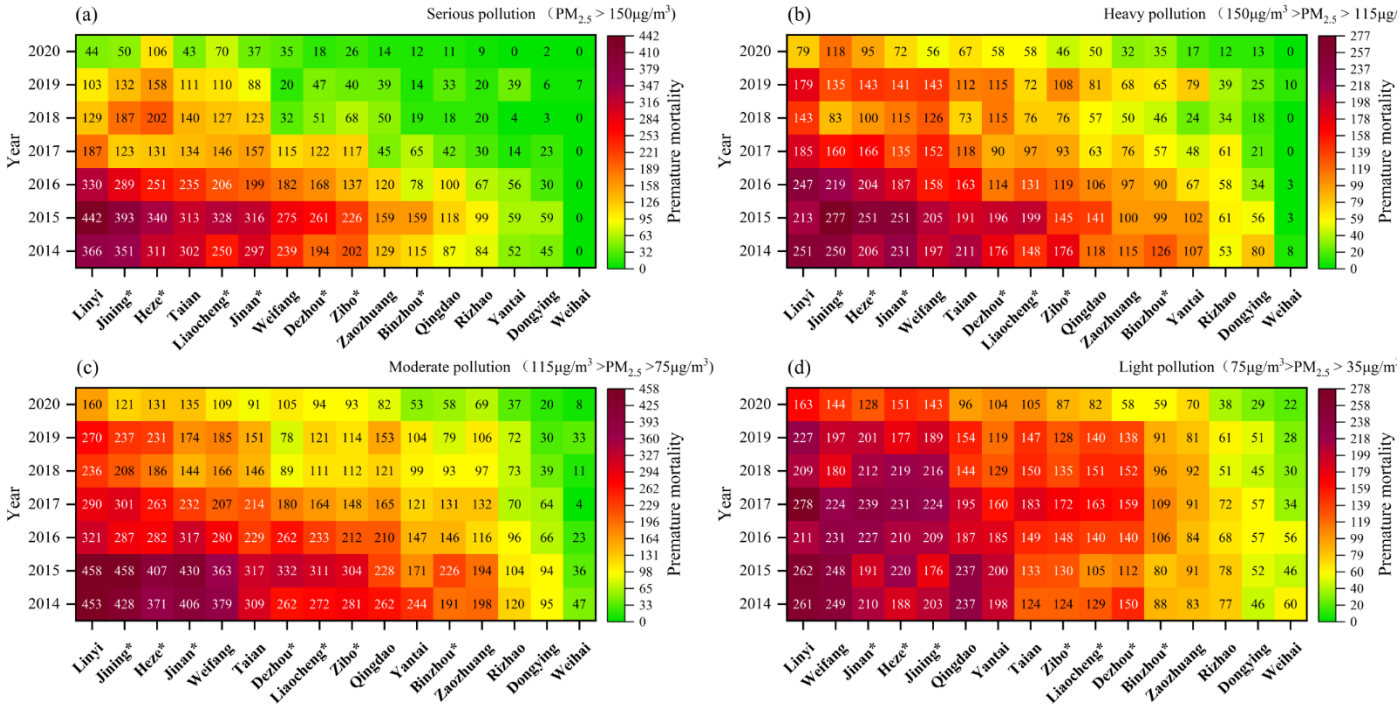

Figure S7. Premature mortality due to short-term exposure to $PM_{2.5}$ in different $PM_{2.5}$ pollution levels by city from 2014 to 2020.

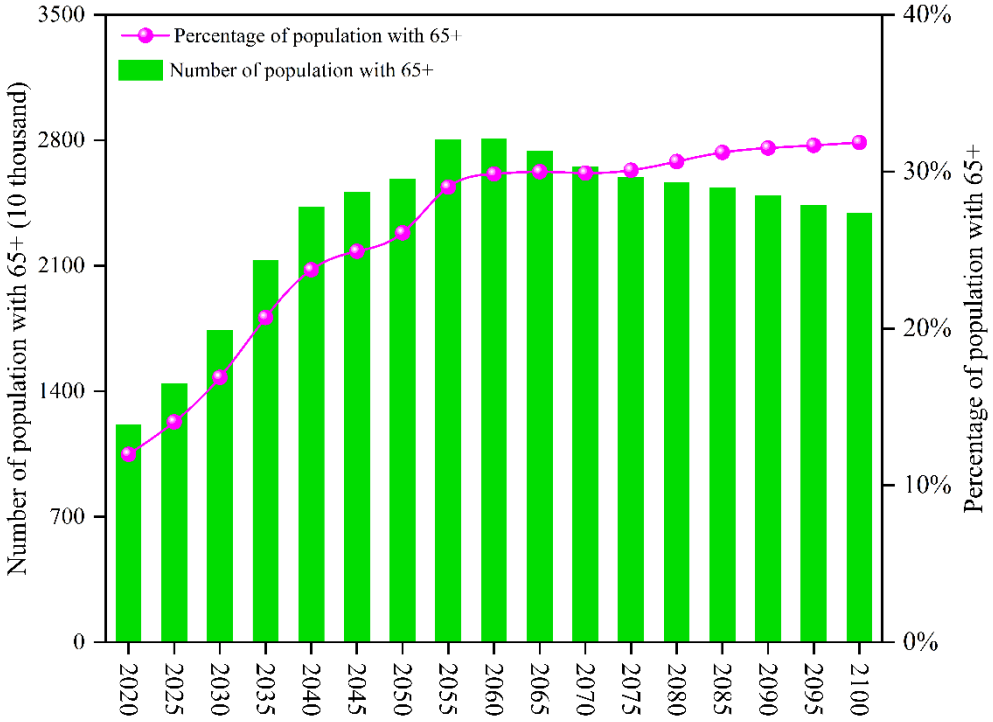

Figure S8. Percentage and number of the population aged 65+ in Shandong province in the future.

Table S1. Fitting parameters and thresholds used in the exposure–response functions.

Exposure type	Pollutant	Exposure–response function	Health end-points	RR	β	C_0 (μg/m³)	Reference
Short-term	O_3	Log-linear	CVD	1.0027 (95%CI:1.001-1.0044) -10μg/m³	0.00027 (95%CI:0.0001-0.00044)	70	(Yin et al., 2017)
			RD	1.0051 (95%CI:1.0003-1.0098) -10μg/m³	0.00051 (95%CI:0.00003-0.00098)		(Madaniyazi et al., 2016)

	$PM_{2.5}$		CVD	1.0063 (95%CI:1.0035-1.0091) -10μg/m^3	0.00063 (95%CI:0.00035-0.00091)		35	(Lu et al., 2015)
			RD	1.0075 (95%CI:1.0039-1.0111) -10μg/m^3	0.00075 (95%CI:0.00039-0.0011)			
	O_3		COPD	1.029 (95%CI:1.015-1.049) -10μg/m3	0.002913 (95%CI:0.001478-0.004766)		70	(Murray et al., 2020)
				α	γ	δ		
Long-term	$PM_{2.5}$	IER	IHD	0.843 (95%CI:0.86-1.2)	0.0724 (95%CI:0.06-0.01)	0.544 (95%CI:0.43-1.16)	6.96	(Burnett et al., 2014; Jiang et al., 2015; Murray et al., 2020)
			CEVD	1.01 (95%CI:1.31-1.41)	0.0164 (95%CI:0.02-0.03)	1.14 (95%CI:0.49-1.08)	8.38	
			COPD	18.3 (95%CI:5.36-75.12)	0.000932 (95%CI:0.00072-0.00044)	0.682 (95%CI:0.85-0.63)	7.17	
			LC	159 (95%CI:19.43-23.41	0.000119 (95%CI:0.000085-0.0017)	0.735 (95%CI:1.02-0.67)	7.24	

Table S2. Baseline mortality data of specific diseases from 2014 to 2020.

Year	Age	IHD (Male, $y_0/10^5$)	IHD (Female, $y_0/10^5$)	CEVD (Male, $y_0/10^5$)	CEVD (Female, $y_0/10^5$)	LC (Male, $y_0/10^5$)	LC (Female, $y_0/10^5$)	COPD (Male, $y_0/10^5$)	COPD (Female, $y_0/10^5$)	CVD (Male, $y_0/10^5$)	CVD (Female, $y_0/10^5$)	RD (Male, $y_0/10^5$)	RD (Female, $y_0/10^5$)
2014	25-29	4.14	1.44	3.74	1.06	0.87	0.71	0.27	0.32	10.73	3.86	1.27	0.99
	30-34	8.65	2.64	8.91	2.57	2.06	1.48	0.69	0.42	21.76	7.05	2.23	1.12
	35-39	12.37	3.57	14.06	4.13	4.01	2.72	1.16	0.71	32.2	9.89	3.17	1.35
	40-44	25.50	7.05	29.71	10.07	11.43	6.17	2.69	1.58	65.06	20.77	5.71	2.74
	45-49	35.23	11.29	44.51	17.22	21.22	10.22	5.27	2.83	92.43	34.63	9.3	4.26
	50-54	73.02	26.06	96.64	43.82	54.99	22.31	14.94	6.66	194.41	81.4	23.16	9.52
	55-59	92.92	36.11	128.29	58.43	89.79	30.31	26.94	10.71	252.7	111.04	37.76	14.62
	60-64	167.71	88.12	252.51	132.90	169.13	60.34	68.64	31.53	480.44	258.27	88.58	40.25
	65-69	288.58	184.09	479.71	281.08	267.42	97.11	157.73	81.59	880.16	541.35	194.53	99.28
	70-74	487.21	353.40	811.60	512.95	372.71	139.50	350.47	183.99	1503.88	1013.06	424.07	222.64
	75-79	880.27	726.13	1392.91	962.85	472.04	210.38	679.76	395.64	2636.95	1976.46	833.29	488.24
	80-84	1757.66	1547.77	2400.40	1823.81	601.05	275.34	1373.94	850.88	4862.97	3967.11	1733.5	1076.84
	85+	4252.47	4074.65	4295.39	3617.77	668.56	329.72	2910.65	2026.48	10134.51	9148.67	3972.74	2810.09
2015	25-29	4.02	1.25	3.83	1.49	0.95	0.52	0.27	0.32	10.37	3.91	1.09	0.87
	30-34	7.78	2.48	8.43	2.26	1.96	1.31	0.77	0.51	20	6.31	1.93	1.05
	35-39	11.85	3.20	13.13	3.81	4.12	2.34	0.92	0.74	30.1	9.03	2.53	1.13
	40-44	23.87	6.76	27.63	9.93	10.91	5.55	2.74	1.31	60.25	19.85	5.25	1.99
	45-49	35.10	10.82	42.46	16.27	20.49	9.90	5.02	2.52	88.9	32.23	8.49	3.54
	50-54	82.10	27.16	101.54	45.67	60.48	24.77	13.98	6.69	206.73	84.83	21.39	9.38
	55-59	89.59	33.63	123.11	53.23	86.01	29.59	24.70	10.17	240.51	100.1	33.23	13.23
	60-64	173.82	86.70	245.92	129.12	179.48	61.80	66.57	29.74	472.67	245.64	84.89	37.01
	65-69	301.75	187.20	480.30	279.48	291.04	104.38	160.24	75.60	882.83	536.06	195.05	91.56
	70-74	490.38	368.97	803.09	522.98	384.83	145.93	347.12	183.50	1462.26	1018.65	414.39	217.63
	75-79	886.25	721.44	1364.51	957.94	481.53	215.44	670.94	377.29	2558.59	1925.85	808.49	460.88
	80-84	1815.06	1615.64	2401.86	1892.90	639.16	290.96	1378.00	853.67	4820.28	4032.59	1720.8	1072.99
	85+	4583.37	4524.50	4538.54	3930.87	759.21	354.22	3106.54	2131.15	10605	9885.44	4188.07	2928.74
2016	25-29	4.22	1.34	3.78	1.55	0.82	0.47	0.27	0.19	10.82	3.95	1.19	0.77
	30-34	8.79	2.23	8.10	2.52	2.10	1.17	0.68	0.49	20.8	6.18	1.9	1.12
	35-39	11.80	3.13	12.18	3.41	3.66	2.24	0.91	0.63	28.23	8.28	2.5	1.18
	40-44	23.01	5.99	25.21	7.26	8.72	5.35	2.72	1.48	56.19	16.69	5.28	2.48
	45-49	37.00	11.29	42.15	14.04	18.63	9.16	4.71	2.27	90.14	32.38	8.29	3.65
	50-54	90.99	30.23	111.10	36.73	64.63	26.36	15.98	7.23	227.98	89.43	24.95	10.1
	55-59	88.96	32.19	114.51	39.47	82.60	25.97	21.53	8.10	228.06	91.7	30.12	11.14
	60-64	188.35	91.33	259.22	108.38	191.27	67.25	67.06	30.89	499.99	254.3	88.2	39.29
	65-69	296.60	181.16	448.91	211.13	275.06	96.78	140.48	66.70	832.59	491.67	174.68	82.72

	70-74	460.93	331.38	717.49	378.14	345.72	126.05	297.36	152.61	1317.34	892.55	356.36	182.39
	75-79	800.98	653.85	1192.19	706.85	422.55	182.14	573.87	268.65	2242.69	1677	690.79	380.13
	80-84	1727.49	1565.92	2244.53	1608.64	576.56	269.71	1205.61	739.66	4506.35	3779.2	1519.32	940
	85+	4641.70	4554.77	4484.24	3980.83	737.07	350.11	2883.24	1990.63	10464.3	9755.22	3948.66	2756.23
	25-29	3.91	1.37	3.56	1.28	0.97	0.50	0.21	0.30	10.12	3.7	1.26	0.72
	30-34	8.12	2.83	7.90	2.49	2.05	1.07	0.67	0.46	19.99	6.73	2.02	1.05
	35-39	12.14	3.15	12.56	3.28	3.49	1.95	0.99	0.59	29.35	8.05	2.39	1.16
	40-44	21.60	6.26	23.46	7.08	8.27	5.15	2.08	0.95	52.93	15.94	4.39	1.93
	45-49	37.41	11.42	41.43	15.13	17.67	8.95	4.38	2.18	90.1	31.1	8.46	3.46
	50-54	95.29	31.26	112.64	49.61	64.84	26.71	15.52	6.96	236.41	93.19	24.39	9.78
2017	55-59	84.76	31.73	105.21	44.07	73.67	24.39	18.85	6.77	212.51	85.9	27.87	9.27
	60-64	190.29	90.61	261.47	126.72	192.52	65.50	65.47	25.92	507.59	246.09	86.47	34.22
	65-69	307.60	186.30	455.77	254.88	292.17	103.14	138.73	59.43	854.28	499.89	174.31	75.84
	70-74	459.26	334.18	711.14	448.14	348.30	129.76	282.71	133.66	1309.86	882.96	343.01	163.93
	75-79	786.22	631.25	1164.29	792.19	430.82	177.31	526.12	277.86	2191.36	1612.18	643.11	341.42
	80-84	1727.91	1579.89	2167.78	1743.54	578.73	276.26	1141.89	681.36	4425.6	3790.21	1450.62	888.71
	85+	4802.40	4745.74	4522.55	3899.79	761.26	373.07	2849.22	1888.29	10772.77	10027.4	3993.22	2677.21
	25-29	3.97	1.39	3.21	1.04	0.90	0.46	0.32	0.09	9.34	3.48	1.47	0.58
	30-34	9.45	2.58	7.99	2.50	1.99	1.07	0.66	0.43	21.66	6.57	2.12	1.27
	35-39	12.69	3.10	11.55	2.96	2.92	1.82	0.89	0.54	29.4	7.98	2.54	1.19
	40-44	21.81	5.74	21.81	6.14	7.33	4.34	1.88	0.96	51.13	14.47	4.35	1.89
	45-49	39.48	11.24	42.23	15.12	17.85	9.04	4.32	1.93	93.43	30.95	8.5	3.52
	50-54	93.40	32.38	105.67	47.25	59.92	25.33	14.69	6.41	225.19	90.97	24.56	9.8
2018	55-59	95.57	33.41	109.85	45.41	77.64	25.16	18.42	6.58	229.84	89.21	28.59	9.84
	60-64	199.20	91.17	255.12	121.67	193.59	63.21	63.95	24.02	508.53	243.05	88.04	32.65
	65-69	312.11	180.99	436.72	244.82	293.44	97.05	134.23	55.63	837.82	481.66	172.28	71.83
	70-74	444.52	317.03	667.76	415.37	339.77	128.66	259.51	123.05	1243.78	833.37	319.95	153.15
	75-79	740.46	587.39	1056.36	735.85	401.41	160.34	463.58	236.20	2019.89	1493.75	578.06	298.11
	80-84	1653.88	1494.24	2068.03	1611.22	538.82	263.29	1044.55	609.29	4214.89	3538.86	1346.64	799.33
	85+	5328.85	4733.41	4541.23	3904.34	762.95	386.64	2681.03	1751.65	10795.75	10042.09	3802.59	2523.45
	25-29	3.23	1.03	2.45	0.86	0.48	0.31	0.19	0.16	7.49	3.14	1.05	0.56
	30-34	7.30	2.04	6.06	1.87	1.61	0.77	0.44	0.25	17.16	5.21	1.8	0.74
	35-39	13.74	3.10	12.39	2.93	3.52	2.13	0.81	0.45	31.38	7.91	2.61	1.08
	40-44	24.12	5.91	23.62	6.89	6.98	4.12	2.06	0.84	56.43	15.25	5.11	1.83
	45-49	39.96	10.36	42.53	14.41	16.28	8.81	4.15	1.80	95.81	29.38	8.5	3.35
	50-54	61.96	19.19	70.90	28.35	37.44	15.68	8.85	3.60	151.56	54.71	15.77	5.76
2019	55-59	109.84	35.70	126.14	48.93	85.01	29.28	18.87	6.18	265.78	97.25	30.14	9.95
	60-64	154.86	66.82	198.86	88.04	148.87	47.05	45.56	16.76	395.43	177.38	65.11	23.5
	65-69	267.36	144.41	368.42	191.30	254.29	81.64	104.28	42.06	707.99	380.62	139.12	55.95
	70-74	469.04	324.38	686.40	419.32	366.21	121.48	246.33	112.62	1293.14	843.25	311.47	143.13
	75-79	896.62	710.47	1266.49	877.79	494.30	194.30	545.73	261.67	2430.19	1796.81	684.1	334.68
	80-84	1674.46	1485.68	2087.20	1572.60	552.39	261.63	1006.70	550.90	4270.5	3501.56	1304.6	732.48
	85+	5119.19	5259.02	4703.61	4312.07	792.27	400.60	2635.23	1799.72	11322.76	11190.44	3782.14	2624.83
	25-29	3.47	1.04	2.47	0.85	0.46	0.34	0.18	0.17	4.78	2.94	0.85	0.41
	30-34	7.85	2.12	6.32	1.65	1.53	0.81	0.38	0.35	11.33	5.1	1.24	0.73
	35-39	14.69	3.16	14.00	3.00	3.39	1.78	0.73	0.31	22.14	8.1	2.28	0.84
	40-44	24.91	5.50	24.98	6.54	6.86	4.21	1.42	0.71	37.89	14.67	3.67	1.58
	45-49	39.12	10.97	42.87	13.83	15.17	8.47	3.30	1.65	66.29	29.02	6.8	3.2
	50-54	62.65	19.42	72.38	28.79	34.73	15.50	7.64	3.20	104.64	55.44	14	5.22
2020	55-59	101.59	32.37	122.65	46.69	76.12	26.72	15.63	5.48	178	91.07	25.71	8.6
	60-64	156.37	64.48	199.69	86.05	148.33	46.06	37.35	12.56	295.72	172.54	55.09	19.49
	65-69	255.26	139.32	360.71	189.76	240.35	79.52	88.00	33.11	531.39	371.32	119.17	45.22
	70-74	455.43	305.21	681.38	409.73	351.13	122.81	207.83	86.55	993.28	811.04	262.79	111.69
	75-79	878.41	680.37	1249.74	827.88	479.88	184.32	458.78	204.82	1904.79	1712.8	569.28	258.49
	80-84	1777.56	1556.05	2229.44	1656.64	565.16	262.77	912.25	469.64	3813.77	3682.32	1146.81	609.98
	85+	4612.53	4560.48	4201.12	3593.59	656.05	332.06	1999.56	1234.44	9574.06	9542.65	2747.28	1699.73

Table S3. Annual average concentrations of $PM_{2.5}$ and O_3 in Shandong province from 2025 to 2060.

Year	$PM_{2.5}$（μg/m³）	O_3（μg/m³）
2025*	40	130
2030**	27	129

2035**	23	123
2060**	11	93

* According to the 14th Five-Year Plan, there will be a 10% reduction by 2025 relative to 2020.
** From simulations by Shi et al. (2021). In combination with the carbon-neutral target Chinese CO2 emission pathway (CAEP-CAP), these results take into account the application and development of end-of-pipe technologies and the "Beautiful China 2035" target.

Table S4. The introduction and implementation of policies related to clean air actions in Shandong province.

Year	Measures and Policies
7/17/2013	"2013-2020 Shandong Province Air Pollution Control Plan"; "Phase I Action Plan (2013-2015)".
9/1/2013	Shandong Province Regional Air Pollutants Emission Standards.
11/1/2015	A joint prevention and control mechanism for air pollution in Shandong's capital city cluster officially launched.
5/19/2016	"2013-2020 Shandong Province Air Pollution Control Plan"; "Phase I Action Plan (2015-2017)".
11/1/2016	Shandong Province Air Pollution Prevention and Control Regulations.
5/25/2017	Shandong Province "Beijing, Tianjin, Hebei and surrounding areas 2017 air pollution prevention and control work programme" implementation rules were introduced. "Opinions on Strengthening Responsibility for Eco-environmental Damage", "Assessment Measures for the Achievement of Air Pollution Prevention and Control Targets and Tasks in Shandong Province", "Programme for the Division of Responsibilities of Air Pollution Prevention and Control Departments in Shandong Province", and "Measures for Environmental Protection Talks in Shandong Province" issued and implemented.
1/7/2020	Implementation Plan for the Comprehensive Treatment of Air Pollution from Industrial Furnaces in Shandong Province.
11/20/2020	Implementation Rules of Shandong Province for Implementing the Action Plan for Comprehensive Control of Air Pollution in Autumn and Winter in Beijing, Tianjin, Hebei and Neighbouring Regions and Fenwei Plain 2020-2021.

Table S5. Top 30 counties with the highest premature mortality rates due to long-term $PM_{2.5}$ exposure from 2014 to 2020.

City	Ename	2014	2015	2016	2017	2018	2019	2020	7-year total
Qingdao	Pingdong	2015	2146	2004	2002	1889	1964	1750	13770
Zaozhuang	Tengzhou	1935	2054	1913	1903	1855	1874	1710	13244
Taian	Xintai	1604	1701	1586	1651	1594	1606	1423	11165
Heze	Caoxian	1485	1602	1496	1518	1492	1516	1416	10525
Linyi	Lanling	1340	1412	1327	1394	1371	1393	1283	9520
Yantai	Laizhou	1449	1511	1422	1442	1349	1436	1275	9884
Heze	Danxian	1328	1438	1350	1374	1360	1380	1274	9504
Weifang	Shouguang	1403	1473	1358	1440	1342	1363	1270	9649
Heze	Mudanqu	1349	1453	1353	1387	1362	1359	1256	9519
Qingdao	Shibeiqu	1547	1578	1498	1347	1298	1365	1233	9866
Jining	Zoucheng	1378	1471	1363	1378	1342	1346	1230	9508
Laiwu	Laichengqu	1293	1367	1282	1411	1349	1356	1223	9281
Heze	Yuncheng	1291	1387	1293	1306	1285	1298	1201	9061
Jining	Renchengqu	1288	1363	1274	1280	1259	1251	1176	8891
Jinan	Zhangqiuqu	1329	1408	1306	1344	1279	1282	1175	9123
Linyi	Yishui	1349	1446	1357	1369	1305	1332	1167	9325
Weifang	Zhucheng	1331	1396	1305	1343	1290	1306	1164	9135
Linyi	Junan	1299	1370	1285	1326	1264	1287	1146	8977

Taian	Daiyuequ	1057	1094	1047	1292	1250	1253	1133	8126
Qingdao	Jimoqu	1245	1379	1320	1324	1245	1286	1111	8910
Taian	Feicheng	1248	1322	1230	1241	1194	1196	1094	8525
Weifang	Qingzhou	1234	1297	1208	1231	1173	1181	1094	8418
Rizhao	Juxian	1270	1367	1279	1291	1232	1252	1082	8773
Liaocheng	Dongchangfu	1183	1277	1183	1145	1108	1096	1036	8028
Weifang	Anqiu	1022	1090	1009	1172	1108	1130	1036	7567
Linyi	Pingyi	1171	1251	1173	1184	1130	1148	1032	8089
Linyi	Feixian	929	999	945	1154	1120	1135	1029	7311
Yantai	Laiyang	1263	1328	1245	1253	1158	1209	1015	8471
Qingdao	Huangdaoqu	1208	1251	1188	1166	1131	1155	1002	8101
Linyi	Yinan	1092	1180	1099	1151	1098	1133	991	7744

Table S6. Premature mortality associated with long-and short-term exposures to $PM_{2.5}$ (95% confidence interval (in thousand)) in Shandong province from 2014 to 2020.

Year	Long-term exposure				Short-term exposure	
	IHD	**CEVD**	**LC**	**COPD**	**CVD**	**RD**
2014	33.66 (23.36,45.73)	54.22 (23.95,69.13)	12.99 (4.76,17.46)	13.94 (7.26,19.44)	7.92 (4.36,11.33)	4.3 (2.19,6.29)
2015	36.28 (25.16,49.3)	56.61 (24.9,72.37)	14.04 (5.16,18.89)	14.59 (7.63,20.44)	8.31 (4.58,11.91)	4.52 (2.31,6.6)
2016	36.17 (25.05,49.44)	51.94 (22.32,67.16)	12.83 (4.43,17.63)	12.51 (6.34,17.86)	6.58 (3.62,9.45)	3.5 (1.73,5.13)
2017	37.03 (25.5,50.7)	54.01 (22.75,70.92)	12.47 (4.08,17.41)	11.47 (5.66,16.67)	5.43 (2.97,7.8)	2.82 (1.4,4.17)
2018	37.07 (25.5,50.85)	51.73 (21.28,69.18)	11.56 (3.55,16.5)	10.12 (4.77,14.94)	4.29 (2.32,6.2)	2.16 (1.04,3.23)
2019	38.03 (26.08,52.34)	52.53 (21.44,70.45)	11.3 (3.48,16.19)	10.17 (4.79,14.99)	4.5 (2.44,6.5)	2.25 (1.11,3.38)
2020	35.56 (24.35,48.75)	48.95 (19.6,67.47)	9.9 (2.79,14.53)	7.36 (3.29,11.15)	2.75 (1.47,4.05)	1.38 (0.66,2.1)

Table S7. Top 30 counties with the highest premature mortality rates due to long-term O_3 exposure from 2014 to 2020.

City	County	2014	2015	2016	2017	2018	2019	2020	7-year total
Qingdao	Pingdong	155	151	162	183	167	176	140	1134
Zaozhuang	Tengzhou	88	89	119	157	172	166	137	928
Qingdao	Shibeiqu	119	144	145	147	112	122	87	876
Yantai	Laizhou	121	103	113	140	126	132	105	840
Weifang	Shouguang	101	116	112	140	122	124	97	812
Taian	Xintai	90	93	103	132	120	130	108	776
Heze	Caoxian	85	86	102	132	125	134	105	769
Jinan	Zhangqiuqu	88	109	101	112	104	111	94	719
Heze	Danxian	78	79	95	119	118	123	101	713
Linyi	Lanlingxian	86	59	87	117	124	124	101	698
Linyi	Yishuixian	92	91	98	115	99	111	89	695
Weifang	Zhucheng	88	93	101	112	100	112	87	693
Jining	Zoucheng	72	78	94	114	117	121	97	693
Heze	Yuncheng	76	82	90	112	113	117	96	686
Heze	Mudanqu	73	79	88	114	116	120	93	683
Laiwu	Laichengqu	80	88	90	117	97	106	93	671
Linyi	Junan	85	77	89	112	107	110	90	670
Qingdao	Jimoqu	89	100	98	105	90	99	81	662
Rizhao	Juxian	87	84	95	106	98	109	81	660
Jining	Renchengqu	71	78	97	104	106	111	91	658
Weifang	Qingzhou	80	91	90	114	94	104	80	653
Yantai	Laiyang	85	97	93	100	84	97	82	638
Taian	Feicheng	74	79	80	97	98	101	86	615
Qingdao	Huangdaoqu	83	81	92	106	76	93	75	606
Weifang	Anqiu	75	79	78	102	91	98	76	599
Weifang	Gaomi	78	78	83	97	88	96	76	596
Liaocheng	Dongchangfu	73	77	79	97	94	94	81	595
Taian	Daiyuequ	62	65	68	105	97	103	89	589
Linyi	Yinan	75	66	80	98	91	98	80	588
Linyi	Pingyi	67	60	76	96	93	102	82	576

Table S8. Premature mortality associated with short-term exposure to O_3 (95% confidence interval) in 16 cities from Shandong province from 2014 to 2020.

City	2014	2015	2016	2017	2018	2019	2020	7-year average
Qingdao	368 (57,675)	308 (38,561)	403 (59,713)	560 (101,995)	621 (120,1104)	660 (132,1177)	595 (115,1055)	502 (89,897)
Dezhou	378 (59,700)	428 (71,762)	449 (73,797)	586 (112,1048)	550 (103,979)	611 (117,1072)	509 (92,921)	502 (90,897)
Jining	350 (60,642)	357 (62,645)	431 (74,761)	520 (96,935)	459 (83,821)	518 (99,909)	445 (82,790)	440 (79,786)
Linyi	326 (42,579)	355 (53,638)	358 (50,648)	454 (72,824)	463 (74,813)	505 (96,906)	504 (87,903)	424 (68,759)
Rizhao	247 (37,462)	257 (39,485)	326 (54,574)	450 (88,810)	496 (102,886)	538 (109,948)	476 (95,865)	399 (75,719)
Weihai	235 (21,429)	267 (26,484)	337 (45,613)	423 (79,773)	487 (94,859)	514 (106,908)	491 (96,887)	393 (67,708)
Tai'an	331 (45,598)	336 (47,605)	329 (44,598)	430 (76,774)	398 (64,727)	476 (88,859)	429 (74,776)	390 (63,705)
Weifang	190 (32,347)	208 (37,380)	233 (41,417)	338 (72,597)	339 (72,595)	380 (77,668)	355 (72,631)	292 (58,519)
Binzhou	207 (12,391)	246 (22,472)	250 (17,457)	314 (37,570)	311 (40,571)	329 (53,618)	318 (48,610)	282 (33,527)
Liaocheng	201 (21,355)	243 (33,434)	242 (32,436)	321 (52,584)	289 (48,526)	348 (63,622)	291 (47,532)	276 (42,498)
Dongying	183 (20,334)	196 (25,372)	211 (27,389)	297 (52,532)	309 (56,560)	334 (65,603)	321 (59,587)	264 (43,482)
Heze	149 (14,265)	162 (17,294)	168 (16,300)	205 (29,366)	220 (33,388)	222 (35,419)	221 (36,405)	192 (26,348)

Zibo	77 (9,158)	71 (10,142)	121 (15,227)	189 (29,334)	230 (36,412)	225 (38,397)	222 (35,389)	162 (25,294)
Jinan	121 (17,220)	124 (19,224)	134 (20,248)	159 (28,284)	168 (30,302)	196 (37,348)	164 (29,298)	152 (26,275)
Yantai	133 (21,246)	133 (22,250)	116 (15,218)	166 (30,304)	130 (19,243)	164 (31,295)	166 (27,303)	144 (24,266)
Zaozhuang	74 (6,143)	85 (10,161)	93 (12,174)	119 (16,220)	119 (16,210)	119 (16,209)	115 (14,204)	103 (13,189)

Table S9. Driving force changes in premature mortality for each health endpoint associated with long-term exposure to $PM_{2.5}$ and O_3, 2014-2020 (unit: thousand).

	$PM_{2.5}$				**O_3**
	ΔMort,IHD	**ΔMort,CEVD**	**ΔMort,LC**	**ΔMort,COPD**	**ΔMort,COPD**
2014	33.7 (23.4,45.7)	54.2 (23.9,69.1)	13.0 (4.8,17.5)	13.9 (7.3,19.4)	7.4 (3.8,11.7)
H_{pop}	1.1 (0.7,1.6)	1.7 (0.6,2.1)	0.3 (0.06,0.4)	0.3 (0.1,0.5)	0.1 (0.05,0.3)
H_{age}	7.5 (5.2,10.4)	10.6 (4.5,13.6)	2.7 (1.1,3.6)	2.7 (1.5,3.8)	1.8 (1.1,2.6)
H_{rate}	1.3 (0.4,3.5)	-2.6 (-4.1,-2.4)	0.1 (-0.2,0.6)	-4.7 (-6.3,-2.7)	-4.7 (-7.5,-2.5)
H_{exp}	-8.0 (-12.5,-5.2)	-14.9 (-17.8,-7.1)	-6.2 (-7.6,-2.9)	-4.9 (-6.2,-2.9)	3.2 (1.7,5.1)
2020	35.6 (24.3,48.7)	48.9 (19.6,63.0)	9.9 (2.8,14.5)	18.8 (9.0,27.8)	7.9 (4.2,12.2)

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