

Supplementary Materials:

The Spatial Variation of the Influence of Lockdown on Air Quality across China and Its Major Influencing Factors during COVID-19

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Table S1. Start and end dates and measures for 55 cases across China

City	Start time and measures	Ending time and measures
Wuhan	January 23, 2020 Wuhan city closure; bus, subway, ferry, long-distance passenger transport shutdown; airport, railway station and other channels to close the Han	April 8, 2020 Release the control measures of the Han channel and restore the external traffic in an orderly manner
Jilin	May 11, 2020 Jilin City enters a state of war, the risk level of the infected area involved is adjusted to medium risk, and the gathering place is closed	June 7, 2020 Territory-wide low risk
Beijing	June 11, 2020 Beijing Fengtai Xinfadi wholesale market outbreak, the city's secondary prevention and control measures, cultural, sports and entertainment venues closed	July 20, 2020 The whole area is downgraded to three levels of prevention and control
Wulumuqi	July 17, 2020 Urumqi begins week-long closure with massive flight cancellations, subway closures and more	August 29, 2020 Territory-wide low risk
Dalian	July 25, 2020 Gathering places are closed; the city's kindergartens are suspended; airports and train stations must have proof of nucleic acid, and bus terminals are suspended from selling tickets	August 16, 2020 Gathering places to resume business; resume group meal operations in the city; resume passenger transport routes
Shanwei	August 15, 2020 The risk level was adjusted upward, and the gathering place was suspended from business	August 28, 2020 Key villages are released from control and the whole area is low risk
Qingdao	October 11, 2020 The risk level was adjusted upward, and the gathering place was suspended from business	October 25, 2020 Territory-wide low risk
Tianjin	November 8, 2020 Tianjin City enters a state of war	December 5, 2020 Territory-wide low risk
Shanghai	November 1, 2020 The risk level was adjusted upward, and the gathering place was suspended from business	December 8, 2020 Territory-wide low risk
Chengdu	December 7, 2020 The risk level was adjusted upward, and the gathering place was suspended from business	December 22, 2020 Territory-wide low risk
Beijing	December 23, 2020 The risk level was adjusted upward, and the gathering place was suspended from business	January 19, 2021 Territory-wide low risk
Shenyang	December 23, 2020 The city of Shenyang entered a state of war	January 20, 2021 Adjusted to low risk
Shijiazhuang	January 5, 2021 Enter a state of war; primary and secondary schools and kindergartens to suspend offline teaching, the city's communities and rural areas to implement closed-loop management	February 22, 2021 Adjusted to low risk
Xingtai	January 5, 2021 Area-wide closure; public transportation ceased operations	February 8, 2021 Territory-wide low risk
Langfang	January 12, 2021 Langfang city-wide closure management	January 19, 2021 Except for Langfang City, Gu'an County, other areas returned to normal
Suihua	January 11, 2021 All communities, villages and towns closed management, gathering activities suspended; import and export closed, traffic control	February 22, 2021 Downgraded to low risk

Jinzhong	January 15, 2021 Suspension of offline teaching in primary and secondary schools and kindergartens	February 8, 2021 Territory-wide low risk
Tonghua	January 18, 2021 City closure, restriction of motor vehicles other than military and police, etc., traffic control; closed management of residential homes	February 20, 2021 Downgraded to low risk; rail, road, air recovery
Haerbin	January 18, 2021 Traffic control, neighborhood control, the city's cinemas and other enclosed places closed	February 18, 2021 Harbin city-wide low risk
Shanghai	January 21, 2021 The risk level was adjusted upward, and the gathering place was suspended from business	February 19, 2021 Territory-wide low risk
Liuan	May 13, 2021 Emergency plan, delineate the control area, the implementation of closed management	June 7, 2021 Territory-wide low risk, Epidemic prevention and control is normalized
Hefei	May 14, 2021 Delineate the control area, the implementation of closed management	June 7, 2021 Territory-wide low risk, Epidemic prevention and control is normalized
Guangzhou	May 21, 2021 Guangzhou suspended all campus gathering activities, graded classification epidemic control	June 28, 2021 Adjusted to low risk, bus, subway, and passenger stations resume; schools resume offline teaching; resume dine-in
Shenzhen	May 30, 2021 Shenzhen suspended all campus gathering activities	June 23, 2021 Resume normal operations; resume provincial control
Foshan	May 30, 2021 Foshan to implement the classification of prevention and control measures	July 6, 2021 Airport resumes operations with low risk across the region
Dongguan	June 18, 2021 Closed control areas of the district to implement closed management, suspend offline teaching; public cultural and sports venues closed	June 27, 2021 Territory-wide low risk, resume provincial control
Nanjing	July 21, 2021 City-wide traffic control, public transportation, long-distance passenger stations, flight suspension; public places suspended business, suspend the gathering activities	August 19, 2021 Territory-wide low risk; Resumption of public transportation, long-distance passenger transportation, flights, etc.
Yangzhou	July 24, 2021 Closure of residential areas; transportation control; designation of control areas; closure of gathering places	September 4, 2021 Territory-wide low risk
Zhuhai	July 26, 2021 Implementation of graded and classified prevention and control measures	August 18, 2021 Unblocked and low risk across the board
Zhangjiajie	July 29, 2021 Closure of gathering places, scenic spots; closure of residential areas; control of stations and public transportation	August 20, 2021 Risk level downgraded, low risk across the region
Zhengzhou	July 30, 2021 Citywide community closed-loop management, non-essential places to suspend business	August 23, 2021 Sealed control area unsealed, low risk across the region
Jingzhou	August 2, 2021 Non-essential places to suspend business; urban cruising cabs, net cars, passenger transport suspended operations	August 15, 2021 Territory-wide low risk
Kaifeng	August 6, 2021 Passenger Terminal Closure	August 27, 2021 Territory-wide low risk
Shangqiu	August 7, 2021 Buses, cabs, online cars, passenger shuttles suspended	September 3, 2021 Blocked area unblocked, Territory-wide low risk
Jinmen	August 4, 2021 Closed management of residential areas; part of the temporary suspension of public transport; non-essential places closed	August 23, 2021 Blocked area unblocked, Territory-wide low risk
Putian	September 13, 2021 Primary and secondary schools and kindergartens suspended offline teaching, the city's closed-loop management; long-distance buses, some trains suspended	October 2, 2021 Return to normal, Territory-wide low risk
Quanzhou	September 11, 2021 Implementation of hierarchical classification of prevention and control	September 28, 2021 Blocked area unblocked, Territory-wide low risk
Xiamen	September 13, 2021 The city's primary and secondary schools and kindergartens to suspend offline teaching; long-distance passenger transport suspended; the city's residential district to implement closed-loop management; all parks, scenic spots, etc. suspended open to the public; the dinners unit to cancel the dine-in	October 29, 2021 Blocked area unblocked, Territory-wide low risk
Zhangzhou	September 19, 2021 The risk level was adjusted upward, and the gathering place was suspended from business	September 29 2021 Return to normal, Territory-wide low risk
Haerbin	September 21, 2021 The city's primary and secondary schools, kindergarten schools online teaching; confined places to suspend business; some trains suspended	October 14, 2021 Territory-wide low risk

Suihua	September 23, 2021 Gathering places are closed for business, Grading and classification of prevention and control	October 8, 2021 Territory-wide low risk
Huhehaote	October 23, 2021 Close confined places, cancel large events; primary and secondary schools, kindergartens closed management	November 1, 2021 Return to normal, Territory-wide low risk
Lanzhou	October 19, 2021 Cultural and tourism business premises and business activities are suspended; emergency suspension of primary and secondary schools, closed management of higher education institutions; closed management of various residential areas	November 16, 2021 Blocked area unblocked, back to normal
Yinchuan	October 17, 2021 Suspension of offline large-scale activities, public places closed management; primary and secondary schools and kindergartens closed	November 4, 2021 Blocked area unblocked, back to normal
Haidong	October 21, 2021 Gathering places are closed for business, Grading and classification of prevention and control	November 4, 2021 Release of control, Territory-wide low risk
Beijing	October 22, 2021 Some areas closed for classes and closure; some bus operations suspended	November 16, 2021 All neighborhoods are unblocked and normal life resumes
Zunyi	October 21, 2021 Risk level up, confined places to suspend business	November 3, 2021 Blocked area unblocked, back to normal
Xining	October 28, 2021 Grading and classification of prevention and control	November 15, 2021 Blocked area unblocked, Territory-wide low risk
Heihe	October 28, 2021 Closed area management; bus, taxi shutdown, traffic control in some areas	November 22, 2021 Blocked area unblocked, Epidemic normalization
Shangrao	October 30, 2021 Closed-loop management, some neighborhood closures; some road traffic restrictions	November 12, 2021 Territory-wide low risk
Chongqing	November 1, 2021 Many districts and counties to suspend the operation of confined places, the implementation of graded classification control	November 14, 2021 Blocked area unblocked, Territory-wide low risk
Chengdu	November 2, 2021 Gathering places are closed for business, Grading and classification of prevention and control	November 14, 2021 Blocked area unblocked, Territory-wide low risk
Tianshui	November 4, 2021 Gathering places are closed for business, Grading and classification of prevention and control	November 16, 2021 Territory-wide low risk
Shijiazhuang	November 6, 2021 City-wide state of emergency and suspension of major events	November 22, 2021 Territory-wide low risk
Haerbin	November 6, 2021 Online teaching in primary and secondary schools, some subway stations suspended operations, some cultural venues closed	November 17, 2021 Territory-wide low risk

Table S2. The variation of multiple airborne pollutants in semi-lockdown and full lockdown cases.

	PM _{2.5}	PM ₁₀	SO ₂	CO	NO ₂	O ₃
Overall	-28.78%	-27.92%	-30.33%	-23.12%	-34.12%	3.82%
Full-lockdown	-34.38%	-36.78%	-42.16%	-33.07%	-41.59%	12.71%
Semi-lockdown	-26.77%	-24.74%	-26.09%	-19.56%	-31.44%	0.63%

Table S3. The variation of multiple airborne pollutants in northern and southern China.

		PM _{2.5}	PM ₁₀	SO ₂	CO	NO ₂	O ₃
North	Overall	-31.79%	-31.07%	-33.77%	-28.81%	-31.51%	10.44%
	Full-lockdown	-36.14%	-37.99%	-42.96%	-37.43%	-37.90%	18.75%
	Semi-lockdown	-29.37%	-27.23%	-28.67%	-24.02%	-27.96%	5.81%
South	Overall	-25.42%	-24.39%	-26.48%	-16.76%	-37.05%	-3.59%
	Full-lockdown	-29.97%	-33.75%	-40.18%	-22.16%	-50.80%	-2.39%
	Semi-lockdown	-24.55%	-22.61%	-23.87%	-15.73%	-34.43%	-3.82%

Table S4. The variation of multiple airborne pollutants in different regions.

	PM _{2.5}	PM ₁₀	SO ₂	CO	NO ₂	O ₃
Northwest China	-16.91%	-32.00%	-25.85%	-26.13%	-35.76%	10.01%
Northeast China	-30.49%	-30.80%	-25.66%	-18.77%	-23.78%	-2.53%
Northern China	-44.23%	-32.49%	-49.47%	-44.28%	-33.92%	27.04%
Eastern China	-31.74%	-24.15%	-26.57%	-15.00%	-26.51%	-7.94%
Southern China	-22.85%	-11.14%	-4.37%	-5.43%	-27.40%	5.25%
Southeast China	-30.54%	-33.90%	-35.92%	-20.57%	-39.01%	-7.13%

Southwest China	-19.42%	-22.63%	-19.36%	-24.04%	-33.91%	-3.94%
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Table S5. The q-value and significance p of each natural and socioeconomic factor on PM_{2.5} changes during lockdown.

variable	q	p
Population density	0.25625309	0.084649826
Per capita GDP	0.17627113	0.236615422
Urban built-up areas	0.18164105	0.342139385
Secondary industry	0.07485082	0.795926741
Private vehicles	0.2776067	0.086348212
Bus	0.08973779	0.855993132
Taxi	0.32098842	0.059201074
Electricity	0.29126249	0.067106982
Industrial smoke	0.11667665	0.658472746
Industrial electricity	0.30166967	0.057052369
Temperature	0.22523372	0.399558743
RH	0.41261528	0.001348716
Precipitation	0.31873945	0.022686611
Pressure	0.13249058	0.412810073
Wind speed	0.23495289	0.136184461

Table S6. The q-value and significance p of each natural and socioeconomic factor on PM₁₀ changes during lockdown.

variable	q	p
Population density	0.3754963	0.080482863
Per capita GDP	0.2031465	0.576472701
Urban built-up areas	0.2015836	0.461649509
Secondary industry	0.1740789	0.26613054
Private vehicles	0.3829376	0.022898782
Bus	0.2463255	0.227799395
Taxi	0.4239739	0.024818044
Electricity	0.3096938	0.276035832
Industrial smoke	0.2111655	0.433327522
Industrial electricity	0.3247304	0.111713479
Temperature	0.467746	0.006223201
RH	0.4877357	0.009869729
Precipitation	0.4101418	0.007755318
Pressure	0.2808636	0.383858898
Wind speed	0.1976512	0.130757021

Table S7. The q-value and significance p of each natural and socioeconomic factor on SO₂ changes during lockdown.

variable	q	p
Population density	0.3336792	0.005124567
Per capita GDP	0.2364133	0.199780158
Urban built-up areas	0.1204732	0.62144743
Secondary industry	0.1333479	0.676680374
Private vehicles	0.2122849	0.160988704
Bus	0.1513292	0.49082178
Taxi	0.3246322	0.045415322
Electricity	0.3453462	0.026331936
Industrial smoke	0.2114794	0.27779951
Industrial electricity	0.2884494	0.025769825
Temperature	0.2805884	0.055025728
RH	0.3296329	0.01922776
Precipitation	0.345415	0.064541174
Pressure	0.1188158	0.365165841
Wind speed	0.2025309	0.225296978

Table S8. The q-value and significance p of each natural and socioeconomic factor on CO changes during lockdown.

variable	q	p
Population density	0.22222763	0.41485481
Per capita GDP	0.2446394	0.43865609
Urban built-up areas	0.15942592	0.31461213
Secondary industry	0.1817126	0.49245468
Private vehicles	0.4495982	0.0220318
Bus	0.24721029	0.3080558
Taxi	0.17447866	0.61658155
Electricity	0.20894632	0.31564834
Industrial smoke	0.17855428	0.56743553
Industrial electricity	0.37781935	0.05587273
Temperature	0.22481537	0.28427417
RH	0.28798862	0.07822534
Precipitation	0.33363304	0.06249821
Pressure	0.17894484	0.55509808
Wind speed	0.14626143	0.30987951

Table S9. The q-value and significance p of each natural and socioeconomic factor on NO₂ changes during lockdown.

variable	q	p
Population density	0.08234353	0.6974995
Per capita GDP	0.0710827	0.76656099
Urban built-up areas	0.19445895	0.06923705
Secondary industry	0.12534097	0.47637984
Private vehicles	0.11447401	0.5170978
Bus	0.13671376	0.40129384
Taxi	0.06440412	0.82140885
Electricity	0.1234493	0.55540864
Industrial smoke	0.14323405	0.24904874
Industrial electricity	0.14254706	0.34374802
Temperature	0.34117666	0.04543127
RH	0.31622542	0.01288435
Precipitation	0.34148417	0.01450756
Pressure	0.17665272	0.16267301
Wind speed	0.06780951	0.80284276

Table S10. The q-value and significance p of each natural and socioeconomic factor on O₃ changes during lockdown.

variable	q	p
Population density	0.2037777	0.37385833
Per capita GDP	0.361404	0.08179644
Urban built-up areas	0.2949269	0.01577863
Secondary industry	0.2351306	0.10052357
Private vehicles	0.3080108	0.09460722
Bus	0.2422	0.24846987
Taxi	0.3496782	0.08148005
Electricity	0.3857156	0.04551656
Industrial smoke	0.1374523	0.41919118
Industrial electricity	0.3402798	0.05191122
Temperature	0.3105306	0.05333131
RH	0.3722889	0.01645511
Precipitation	0.3681042	0.03633055
Pressure	0.1784824	0.33897327
Wind speed	0.2408258	0.15186725