

THE LANCET

Supplementary appendix

This appendix formed part of the original submission and has been peer reviewed. We post it as supplied by the authors.

Supplement to: Leung K, Wu JT, Liu D, Leung GM. First-wave COVID-19 transmissibility and severity in China outside Hubei after control measures, and second-wave scenario planning: a modelling impact assessment. *Lancet* 2020; published online April 8. [http://dx.doi.org/10.1016/S0140-6736\(20\)30746-7](http://dx.doi.org/10.1016/S0140-6736(20)30746-7).

Supplementary Information

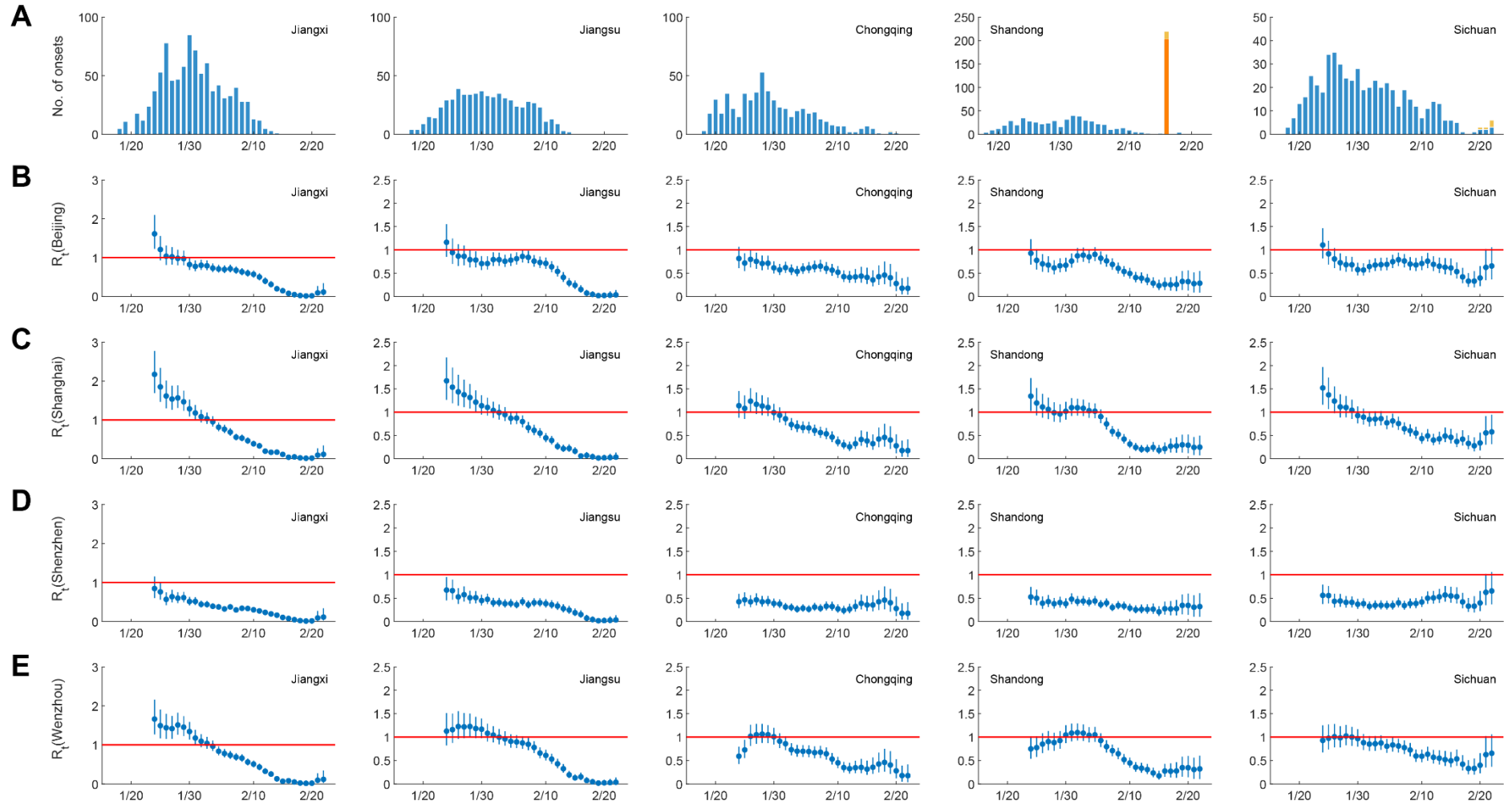


Figure S1. Estimates of R_t of Jiangxi, Jiangsu, Chongqing, Shandong and Sichuan. (A) The epidemic curves by estimated date of illness onset stratified by reported cases (blue) and estimated cases not reported yet due to the time delay between onset and reporting (yellow). We assumed the distribution of the time between onset and reporting in all provinces was the same as Beijing, with a mean of 4.9 days. The epidemic curves were estimated from cases reported on or before 29 February 2020. The Rencheng prison cluster (orange) reported on 21 February in Shandong was not included in the R_t estimation. (B-E) The estimates of R_t assuming the daily proportion of imported cases from Hubei was the same as Beijing, Shanghai, Shenzhen and Wenzhou.

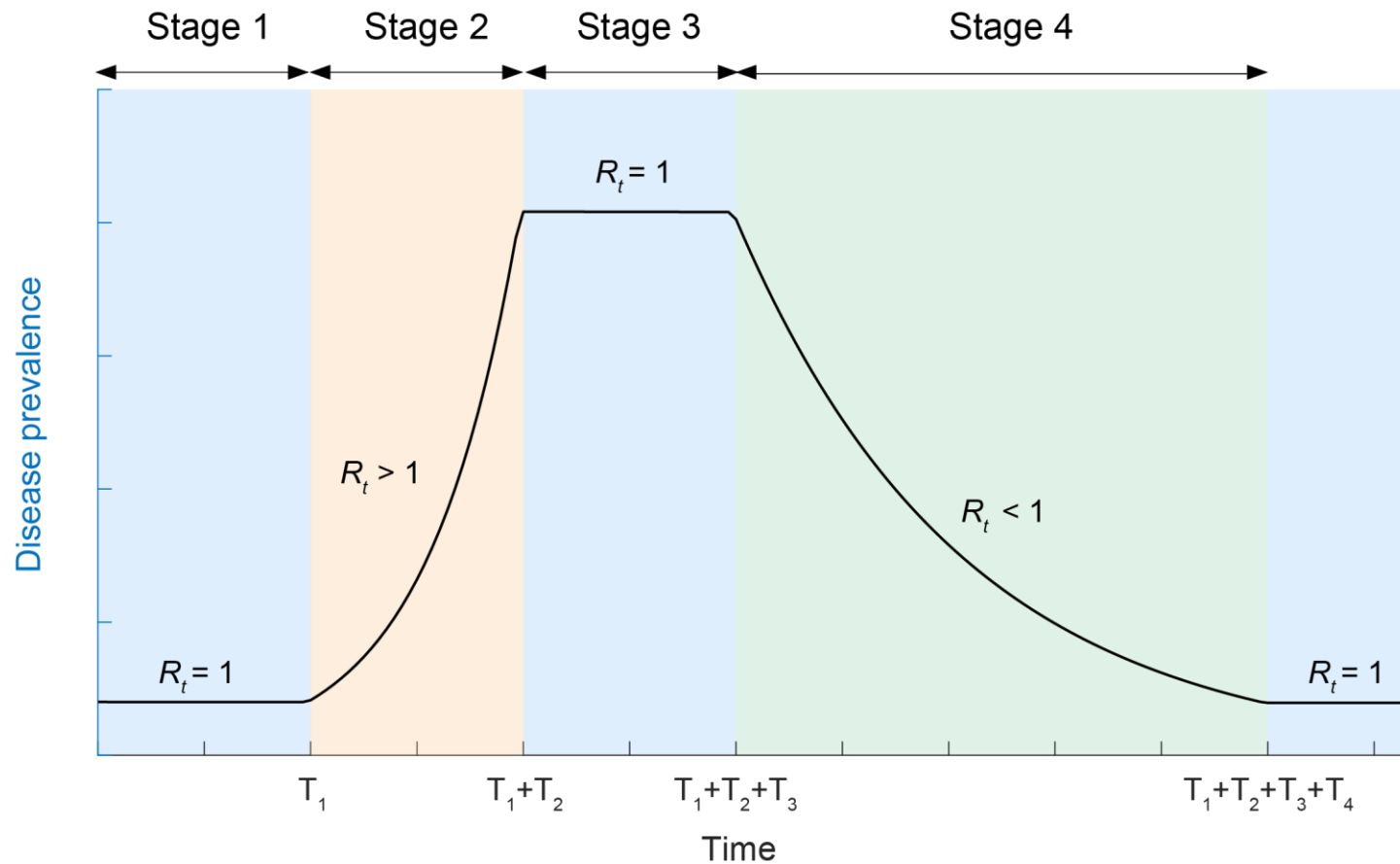


Figure S2. Simulating the adverse effects of relaxation of interventions. Stage 1: Interventions were implemented such that $R_t = 1$; Stage 2: Interventions were relaxed resulting in $R_t = R_2 > 1$ when stage 2 began; Stage 3: Interventions from stage 1 were again implemented such that $R_t = 1$; Stage 4: Interventions more aggressive than that in stages 1 and 3 ($R_t = R_4 < 1$ at the start of stage 4) were implemented in order to push the disease prevalence back to pre-relaxation level (i.e. stage 1 level). T_i is the duration of stage i .

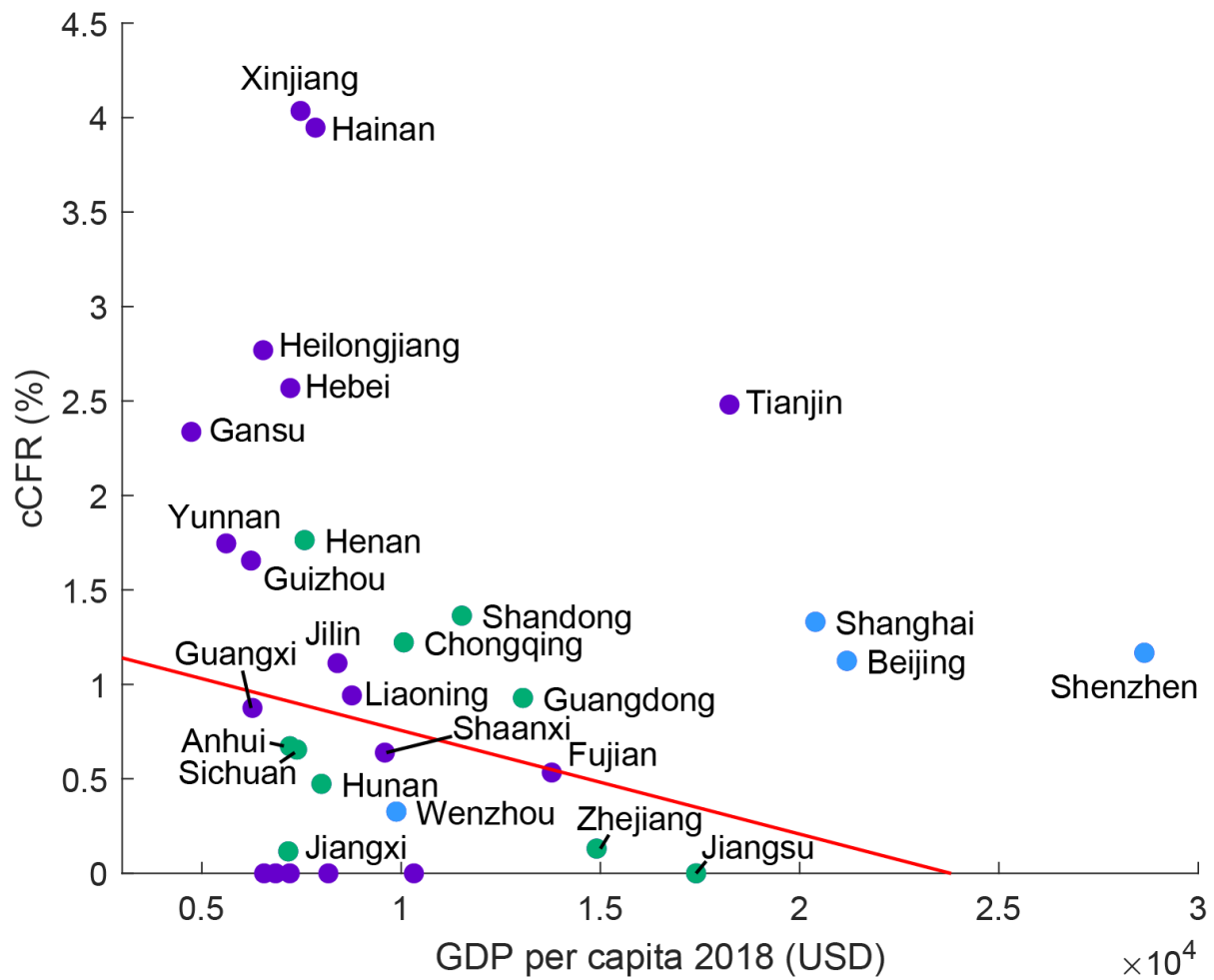


Figure S3. Correlation of cCFR and GDP per capita in Beijing, Shanghai, Shenzhen and Wenzhou and in provinces outside Hubei. Dots in blue show Beijing, Shanghai, Shenzhen and Wenzhou; dots in green show the ten provinces that reported largest number of cases; dots in purple show the other provinces. The red line is the univariate linear regression line using cCFR and GDP per capita from the ten provinces that reported the largest number of cases. The Pearson's correlation coefficient is -0.34 (p-value = 0.33).

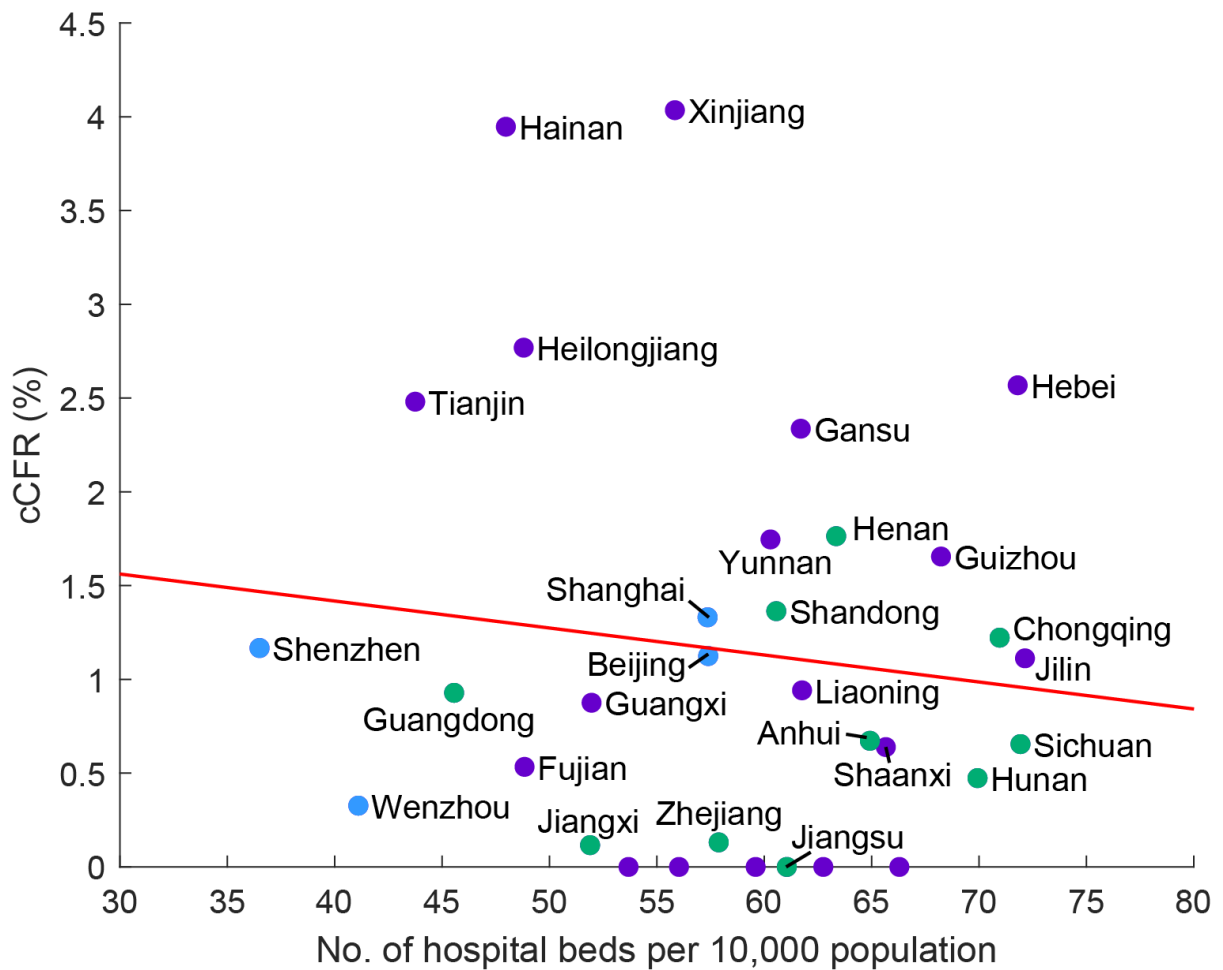


Figure S4. Correlation of cCFR and the number of hospital beds per 10,000 in Beijing, Shanghai, Shenzhen and Wenzhou and in provinces outside Hubei. Dots in blue show Beijing, Shanghai, Shenzhen and Wenzhou; dots in green show the ten provinces that reported largest number of cases; dots in purple show the other provinces. The red line is the univariate linear regression line using cCFR and the no. of hospital beds per 10,000 from all the 31 provinces. The Pearson's correlation coefficient is -0.13 (p-value = 0.50).

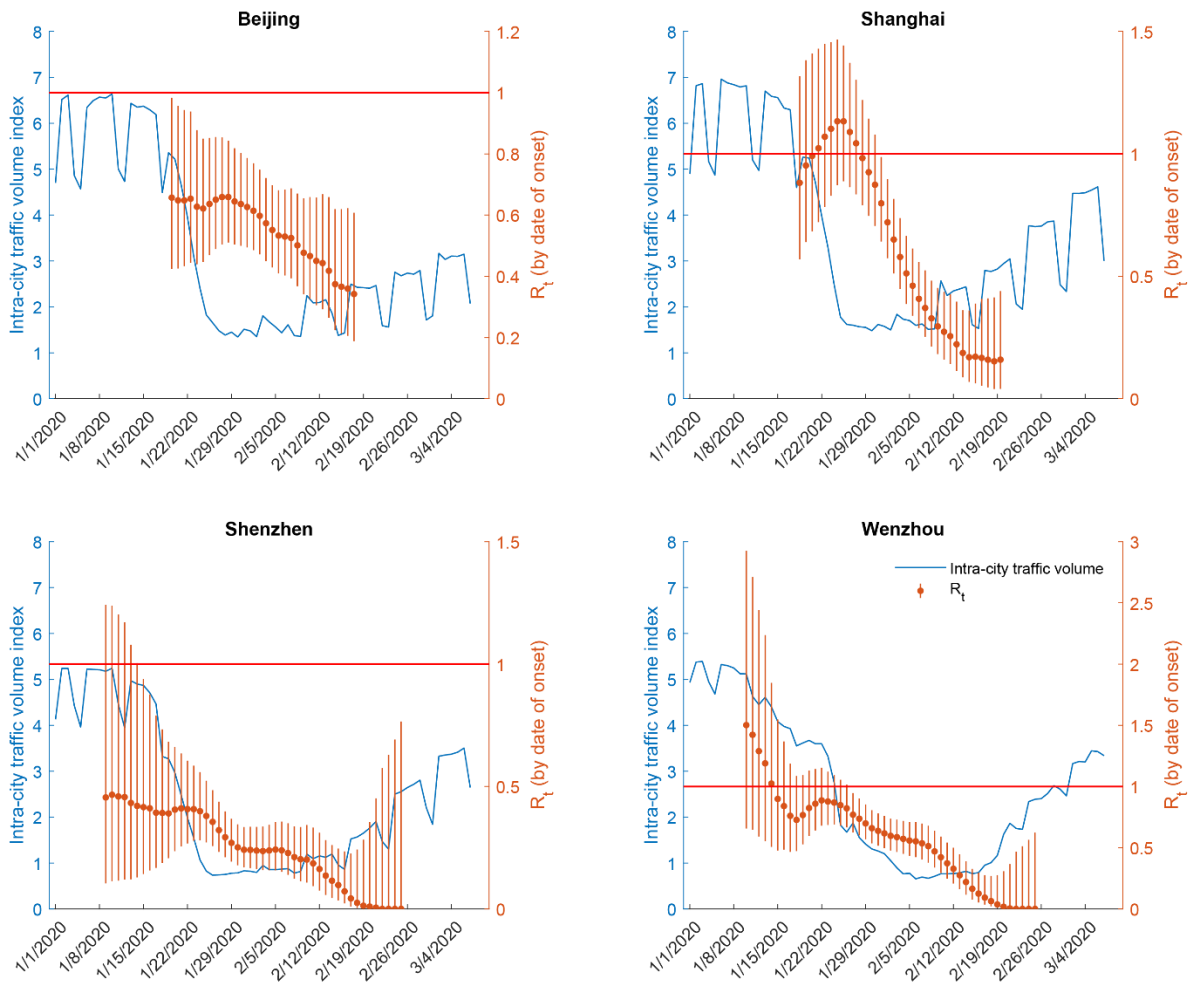


Figure S5. Estimates of R_t in Beijing, Shanghai, Shenzhen and Wenzhou and the Baidu index of intra-city traffic volumes in January-February 2020. R_t estimates are 7-day moving averages of those in Figure 2. Indices of intra-city traffic volumes were obtained from <https://qianxi.baidu.com/>. The Baidu index of intra-city traffic volume is a normalized ratio of a city's population with intra-city movement within 24 hours to a city's residential population, though the precise details of the normalization algorithm have not been made available on the Baidu Qianxi website.

Table S1. Dates of symptom onset of infector-infectee pairs

Region	Age of index patient	Sex of index patient	Date of arrival of index patient	Date of onset of index patient	Age of secondary patient	Sex of secondary patient	Date of onset of secondary patient	Serial interval	Source of secondary patient
Wuhan	61	M		12/20/2019	57	F	12/25/2019	5	Li et al, NEJM
Wuhan	61	M		12/20/2019	31	F	12/29/2019	9	Li et al, NEJM
Wuhan	62	F		12/27/2019	64	M	1/3/2020	7	Li et al, NEJM
Wuhan	49	M		12/12/2019	78	M	12/19/2019	7	Li et al, NEJM
Wuhan	52	F		12/21/2019	25	F	12/24/2019	3	Li et al, NEJM
Huanggang	32	M		1/4/2020	28	F	1/11/2020	7	Li et al, NEJM
Shenzhen	65, 66, 37, 36	F, M, F, M	1/4/2020	1/1/2020 - 1/4/2020	63	F	1/8/2020	4-7	Chan et al, Lancet
Chicago	60+	F	1/13/2020	1/22/2020 - 1/23/2020	60+	M	1/28/2020	5-6	6th case in US
Taiwan	40+	M	1/12/2020	1/21/2020	40+	F	1/27/2020	6	9th case in Taiwan
Hong Kong	73, 72	F, M	1/22/2020	1/22/2020 - 1/25/2020	37	F	1/28/2020	3-6	11th case in Hong Kong
Hong Kong	39	M	1/23/2020	1/29/2020	72	F	2/1/2020	3	15th case in Hong Kong
Singapore	28	F	Local infection	1/29/2020	45	M	2/1/2020	3	27th case in Singapore
Singapore	28	F	Local infection	1/29/2020	44	F	2/2/2020	4	21st case in Singapore
Vietnam	23	F	1/17/2020	1/25/2020	42	F	1/31/2020	6	10th case in Vietnam
Vietnam	23	F	1/17/2020	1/25/2020	49	F	2/3/2020	9	11th case in Vietnam
Vietnam	23	F	1/17/2020	1/25/2020	16	F	2/3/2020	9	12th case in Vietnam
Hong Kong	60	M	Local infection	1/22/2020	28	F	1/30/2020	8	19th case in Hong Kong
Hong Kong	60, 28	M, F	Local infection	1/22/2020 - 1/30/2020	56	F	2/4/2020	6-14	20th case in Hong Kong
Malaysia	42	M	1/23/2020	1/29/2020	40	F	2/1/2020	3	14th case in Malaysia
Shenzhen	64	F	Local infection	1/4/2020	69	M	1/12/2020	8	12nd case
Shenzhen	69	M	1/15/2020	1/12/2020	25	F	1/25/2020	13	188th case
Shenzhen	64, 71	F, M	1/12/2020	1/12/2020 - 1/15/2020	38	F	1/22/2020	7-10	39th case
Shenzhen	73	M	1/19/2020	1/20/2020	49	M	1/24/2020	4	68th case
Shenzhen	73	M	1/19/2020	1/20/2020	49	F	1/22/2020	2	69th case
Shenzhen	62	F	1/22/2020	1/19/2020	43	F	2/4/2020	16	320th case

Shenzhen	30	F	1/21/2020	1/22/2020	38	F	1/28/2020	6	108th case
Shenzhen	61	M	1/22/2020	1/24/2020	35	F	1/26/2020	2	120th case
Shenzhen	61	M	1/22/2020	1/24/2020	39	M	1/26/2020	2	121st case
Shenzhen	61, 35, 39	M, F, M	1/24/2020	1/24/2020 - 1/26/2020	2	M	2/5/2020	10-12	327th case
Shenzhen	61, 35, 39	M, F, M	1/22/2020	1/24/2020 - 1/26/2020	62	F	2/5/2020	10-12	345th case
Shenzhen	64	F	1/22/2020	1/17/2020	37	F	1/28/2020	11	275th case
Shenzhen	34	M	1/20/2020	1/20/2020	32	M	1/23/2020	3	100th case
Shenzhen	34	M	1/20/2020	1/20/2020	32	M	1/25/2020	5	101st case
Shenzhen	34	M	1/20/2020	1/20/2020	34	M	1/26/2020	6	102nd case
Shenzhen	64	M	1/17/2020	1/18/2020	37	M	1/24/2020	6	169th case
Shenzhen	78	M	1/16/2020	1/26/2020	78	F	1/30/2020	4	283rd case
Shenzhen	59, 61	F, M	1/21/2020	1/24/2020	34	F	1/25/2020	1	253rd case
Shenzhen	50	F	Local infection	1/26/2020	37	F	2/5/2020	10	354th case
Shenzhen	42	M	Local infection	1/20/2020	6	M	2/6/2020	17	340th case
Shenzhen	69	M	Local infection	1/21/2020	66	F	2/2/2020	12	335th case
Shenzhen	69	M	1/20/2020	2/9/2020	69	F	2/10/2020	1	402nd case
Shenzhen	69	M	1/20/2020	2/9/2020	49	M	2/10/2020	1	397th case
Zhuhai	78, 76	M, F	1/11/2020	1/15/2020-1/18/2020	49	F	1/18/2020	0-3	3rd case
Zhuhai	37	F	1/22/2020	1/26/2020	67	F	1/26/2020	0-1	45th case
Nanjing	P6, P7	M, F	Local infection	1/27/2020-1/28/2020	P8	M	2/1/2020	4-5	Huang et al, Lancet ID
Nanjing	P6, P7	M, F	Local infection	1/27/2020-1/28/2020	P9	F	1/28/2020	0-1	Huang et al, Lancet ID
Nanjing	P6, P7, P9	M, F, F	Local infection	1/27/2020-1/28/2020	P10	M	1/31/2020	3-4	Huang et al, Lancet ID
Nanjing	P4	M	Local infection	1/25/2020	P5	F	1/27/2020	2	Huang et al, Lancet ID
Nanjing	P1, P2, P3, P4, P6, P7	-	Local infection	1/25/2020-1/31/2020	Index	M	1/28/2020	-3-3	Huang et al, Lancet ID
Nanjing	Index, P2, P3, P4, P6, P7	-	1/21/2020, Local infection	1/25/2020-1/31/2020	P1	F	1/26/2020	-5-1	Huang et al, Lancet ID
Nanjing	Index, P1, P3, P4, P6, P7	-	1/21/2020, Local infection	1/25/2020-1/31/2020	P2	F	1/25/2020	-6-1	Huang et al, Lancet ID
Nanjing	Index, P1, P2, P4, P6, P7	-	1/21/2020, Local infection	1/25/2020-1/28/2020	P3	F	1/31/2020	3-6	Huang et al, Lancet ID
Nanjing	Index, P1, P2, P3, P6, P7	-	1/21/2020, Local infection	1/25/2020-1/31/2020	P4	M	1/25/2020	-6-1	Huang et al, Lancet ID

Nanjing	Index, P1, P2, P3, P4, P7	-	1/21/2020, Local infection	1/25/2020-1/31/2020	P6	M	1/28/2020	-3-3	Huang et al, Lancet ID
Nanjing	Index, P1, P2, P3, P4, P6	-	1/21/2020, Local infection	1/25/2020-1/31/2020	P7	F	1/27/2020	-4-2	Huang et al, Lancet ID

Table S2. The time between onset and death or the time between admission and death for 41 death cases of 2019-nCoV in Wuhan

Sex	Age	Date of symptom onset	Date of first admission	Death date	Time between onset to death	Time between admission to death
M	61	12/20/2019	12/27/2019	1/9/2020	20	13
M	69	12/25/2019	12/31/2019	1/15/2020	21	15
M	89	1/5/2020	1/8/2020	1/18/2020	13	10
M	89	1/13/2020	1/13/2020	1/19/2020	6	6
M	75	1/4/2020	1/11/2020	1/20/2020	16	9
F	69		1/14/2020	1/20/2020		6
M	66	1/10/2020	1/16/2020	1/20/2020	10	4
F	48	12/10/2019	12/10/2019	1/20/2020	41	41
M	86	1/2/2020	1/9/2020	1/21/2020	19	12
F	85		11/26/2019	1/21/2020		56
M	82	1/9/2020	1/14/2020	1/21/2020	12	7
M	81	1/9/2020	1/13/2020	1/21/2020	12	8
F	70		1/13/2020	1/21/2020		8
F	66	1/8/2020	1/19/2020	1/21/2020	13	2
M	66	12/22/2019	12/22/2019	1/21/2020	30	30
M	66		1/11/2020	1/21/2020		10
M	65	1/5/2020	1/11/2020	1/21/2020	16	10
M	53		1/13/2020	1/21/2020		8
M	84	1/6/2020	1/9/2020	1/22/2020	16	13
F	82	1/3/2020	1/3/2020	1/22/2020	19	19
M	81		1/18/2020	1/22/2020		4
F	80		1/11/2020	1/22/2020		11
M	73	12/30/2019	1/5/2020	1/22/2020	23	17
F	70		1/18/2020	1/22/2020		4
M	87	1/12/2020	1/19/2020	1/23/2020	11	4
F	82	1/10/2020	1/17/2020	1/23/2020	13	6
M	72	1/11/2020	1/18/2020	1/23/2020	12	5
M	70	1/15/2020	1/19/2020	1/23/2020	8	4
F	67	1/10/2020	1/12/2020	1/24/2020	14	12
M	65	1/12/2020	1/16/2020	1/23/2020	11	7
M	58	1/1/2020	1/1/2020	1/24/2020	23	23
M	36	1/6/2020	1/9/2020	1/23/2020	17	14
M	79	1/11/2020	1/17/2020	1/24/2020	13	7
M	78	1/13/2020	1/23/2020	1/24/2020	11	1
F	76		1/5/2020	1/24/2020		19
M	67	1/10/2020	1/15/2020	1/24/2020	14	9
M	58	1/3/2020	1/18/2020	1/24/2020	21	6
M	55	1/8/2020	1/19/2020	1/24/2020	16	5
F	73		1/23/2020	1/28/2020		5
F	73			1/26/2020		
F	31	1/21/2020	1/23/2020	1/26/2020	5	3

Table S3. GDP per capita in 2017 and the number of hospital beds per 10,000 in 2018 for the 31 provinces, Shenzhen and Wenzhou in mainland China

Province or city	GDP per capita in 2018 (Chinese Yuan)	GDP per capita in 2018 (USD)	Number of hospital beds per 10,000 in 2018
Shenzhen	189,600	28,647	36.5
Beijing	140,211	21,184	57.39
Shanghai	134,982	20,394	57.36
Tianjin	120,711	18,238	43.75
Jiangsu	115,168	17,401	61.05
Zhejiang	98,643	14,904	57.88
Fujian	91,197	13,779	48.84
Guangdong	86,412	13,056	45.56
Shandong	76,267	11,523	60.56
Inner Mongolia	68,302	10,320	62.75
Chongqing	66,616	10,065	70.96
Hubei	65,933	9,962	66.51
Wenzhou	65,388	9,879	41.1
Shaanxi	63,477	9,591	65.66
Liaoning	58,008	8,764	61.76
Jilin	55,611	8,402	72.14
Ningxia	54,094	8,173	59.6
Hunan	52,949	8,000	69.93
Hainan	51,955	7,850	47.97
Henan	50,152	7,577	63.35
Xinjiang	49,475	7,475	55.84
Sichuan	48,883	7,386	71.93
Hebei	47,772	7,218	71.8
Anhui	47,712	7,209	64.92
Qinghai	47,690	7,205	53.68
Jiangxi	47,434	7,167	51.89
Shanxi	45,328	6,849	56.03
Tibet	43,433	6,562	66.29
Heilongjiang	43,274	6,538	48.8
Guangxi	41,489	6,269	51.96
Guizhou	41,244	6,232	68.23
Yunnan	37,136	5,611	60.29
Gansu	31,336	4,735	61.7

Table S4. Baidu population outflow index from Hubei and the proportion of the population outflow from Hubei to Beijing, Shanghai, Shenzhen and Wenzhou, in January and February 2020 (www.qianxi.baidu.com)

Date	Population outflow index from Hubei*	Percentage in the population outflow from Hubei			
		Beijing	Shanghai	Shenzhen	Wenzhou
1/1/2020	2.56	3	2.82	2.79	0.58
1/2/2020	3.13	3.63	2.87	2.92	0.74
1/3/2020	4.26	3.31	2.8	2.57	0.65
1/4/2020	4.88	3.08	2.71	2.58	0.67
1/5/2020	4.58	4.07	3.09	2.65	0.65
1/6/2020	4.67	3.78	2.7	2.25	0.67
1/7/2020	5.11	3.53	2.67	2.19	0.67
1/8/2020	5.77	3.47	2.58	2.1	0.68
1/9/2020	6.32	3	2.38	2.22	0.71
1/10/2020	5.3	3.1	2.44	2.05	0.69
1/11/2020	5.16	2.7	2.37	2.07	0.66
1/12/2020	4.69	2.66	2.06	2.14	0.57
1/13/2020	4.69	2.97	2.44	2.15	0.63
1/14/2020	4.6	2.81	2.2	1.86	0.63
1/15/2020	4.86	2.58	2	1.92	0.69
1/16/2020	4.85	2.65	2.01	1.85	0.66
1/17/2020	5.1	2.28	1.81	1.8	0.63
1/18/2020	5.42	1.92	1.58	1.73	0.7
1/19/2020	5.49	1.77	1.45	1.81	0.68
1/20/2020	6.03	1.53	1.3	1.78	0.76
1/21/2020	7.21	1.44	1.13	1.87	0.75
1/22/2020	6.8	1.41	1.14	1.98	0.71
1/23/2020	6.21	1.43	1.36	2.1	0.63
1/24/2020	4.59	1.86	2	3.21	0.6
1/25/2020	4.39	2.85	2.71	5.63	0.48
1/26/2020	5.2	3.14	3.23	10.62	0.68
1/27/2020	1.98	2.65	2.95	12.06	0.74
1/28/2020	0.87	2.15	2.3	9.57	0.65
1/29/2020	0.54	1.61	1.83	8.05	0.61
1/30/2020	0.4	1.12	1.4	5.17	0.39
1/31/2020	0.37	1.07	1.19	4.74	0.35
2/1/2020	0.33	0.96	1.16	3.68	0.23
2/2/2020	0.48	1.22	1.75	3.39	0.39
2/3/2020	0.34	1.02	1.48	4.05	0.15
2/4/2020	0.32	1.16	1.37	2.85	0.21
2/5/2020	0.31	1.2	1.15	3.02	0.11
2/6/2020	0.31	1.1	1.65	2.72	0.15
2/7/2020	0.3	0.86	1.47	2.53	0.11
2/8/2020	0.31	0.73	1.59	2.89	0.09
2/9/2020	0.32	1.01	1.44	2.79	0.09

2/10/2020	0.33	1.06	1.6	2.8	0.07
2/11/2020	0.32	1.18	1.81	2.62	0.16
2/12/2020	0.34	1.11	1.63	3.08	0.08
2/13/2020	0.39	1.16	1.83	3.19	0.12
2/14/2020	0.49	1.11	1.81	3.38	0.09
2/15/2020	0.41	1.35	2.61	4.03	0.12
2/16/2020	0.36	1.05	2.12	4.46	0.09
2/17/2020	0.36	0.91	1.57	3.54	0.13
2/18/2020	0.38	0.81	2.33	3.83	0.12
2/19/2020	0.4	0.88	2.06	3.6	0.1
2/20/2020	0.42	0.83	2.25	4.02	0.07
2/21/2020	0.47	0.75	2.51	4.13	0.14
2/22/2020	0.58	0.67	2.78	4.51	0.21
2/23/2020	0.72	0.58	3.71	6.4	0.23
2/24/2020	0.82	0.58	3.28	6.94	0.21
2/25/2020	0.94	0.32	3.21	7.94	0.27
2/26/2020	0.9	0.31	3.08	9.13	0.36
2/27/2020	0.45	0.55	2.58	5.45	0.39
2/28/2020	0.32	0.8	1.31	2.95	0.33
2/29/2020	0.3	0.66	0.86	1.97	0.2

* The Baidu population outflow index is a normalized ratio of a city/province's population traveling outside the city/province within 24 hours to a city/province's residential population, although the precise details of the normalization algorithm have not been made available on the Baidu Qianxi website.

Supplementary Text

We used the following SIR model to simulate the scenarios in Figure 5.

$$\frac{dS(t)}{dt} = -\frac{S(t)Y(t)}{N} \frac{I(t)}{T_g}$$

$$\frac{dI(t)}{dt} = \frac{S(t)Y(t)}{N} \frac{I(t)}{T_g} - \frac{I(t)}{T_g}$$

$$Y(t) = \begin{cases} 1 & \text{if } 0 < t \leq T_1; \\ R_2 N/S(T_1) & \text{if } T_1 < t \leq T_1 + T_2; \\ N/S(T_1 + T_2) & \text{if } T_1 + T_2 < t \leq T_1 + T_2 + T_3; \\ R_4 N/S(T_1 + T_2 + T_3) & \text{if } T_1 + T_2 + T_3 < t \leq T_1 + T_2 + T_3 + T_4; \end{cases}$$

where N was the population size (assumed to be 10 million); $S(t)$ and $I(t)$ were the total number of susceptible and infectious individuals at time t (epidemic was seeded with 100 infections at time 0); T_g was the mean generation time (assumed to be 7 days); T_i was the duration of stage i ; and R_2 and R_4 were the reproductive number at the beginning of stages 2 and 4, respectively.

Supplementary References

Source of information for events shown in Figure 1:

1. "Wuhan halts travel to contain coronavirus". China Daily. Retrieved 20 February 2020. <https://global.chinadaily.com.cn/a/202001/23/WS5e299a4ea3101282172730f2.html>
2. James Griffiths; Amy Woodyatt. "Wuhan coronavirus: Thousands of cases confirmed as China goes into emergency mode". CNN. Retrieved 20 February 2020. <https://edition.cnn.com/2020/01/26/asia/wuhan-coronavirus-update-intl-hnk/index.html>
3. "China to extend Spring Festival holiday to contain coronavirus outbreak". Xinhua. Retrieved 20 February 2020. http://www.xinhuanet.com/english/2020-01/26/c_138735589.htm
4. Evelyn Cheng. "More than half of China extends shutdown over virus". CNBC. Retrieved 20 February 2020. <https://www.cnbc.com/2020/02/01/coronavirus-more-of-china-extend-shutdown-accounting-for-80percent-of-gdp.html>
5. Alice Yan. "China's private sector business capital on lockdown as coronavirus takes its toll". SCMP. Retrieved 20 February 2020. <https://www.scmp.com/news/china/society/article/3048610/chinas-private-sector-business-capital-lockdown-coronavirus>
6. "Under China's coronavirus lockdown, millions have nowhere to go". Reuters. Retrieved 20 February 2020. <https://www.reuters.com/article/us-china-health-scale/under-chinas-coronavirus-lockdown-millions-have-nowhere-to-go-idUSKBN2081DB>
7. "China Focus: Back to work, enterprises gradually resume operation amid epidemic outbreak". Xinhua. Retrieved 20 February 2020. http://www.xinhuanet.com/english/2020-02/10/c_138771875.htm
8. Cao Yin and Zhou Lihua. "Hubei district launches wartime control order to better fight virus". China Daily. Retrieved 20 February 2020. <http://www.chinadaily.com.cn/a/202002/13/WS5e44ba07a310128217277470.html>
9. "China Gradually Gets Back to Work in Face of Worker, Material Shortages". Caixin. Retrieved 20 February 2020. <https://www.caixinglobal.com/2020-02-19/coronavirus-wednesday-update-death-toll-passes-2000-as-russia-announces-ban-on-chinese-citizens-101517506.html>