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Supplementary: Meta-analysis of several epidemic characteristics of COVID-19

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Summary

In this supplementary document, we give the details about the studies that are collected for this meta-analysis as well as the graphic representations of the analysis results. Specifically for the collected studies (in Tables A1 to A4), we present the point estimates of the epidemiological metrics and their associated 95% confidence intervals (in terms of lower bounds (L.B.) and upper bounds (U.B.)). Besides, we provide some additional information about these studies, such as sample size and study period. Note that in some of the studies, the authors stated that they obtained the data from publicly available online sources (such as the Chinese Center for Disease Control and Prevention) without specifying the exact number of sample size, which are marked as "`na`" in the summary tables.

Basic Reproduction Number

We list the sources that are utilized for estimating R_0 via meta-analysis in Table A1. In Sun et al. (2020); Zhu and Chen (2020), multiple estimates of R_0 and associated confidence intervals were reported. We selected the the most appropriate one based on the proposed models, estimation time and some other decisive factors. Specifically, we considered the study period before January 23, 2020 (if available), the date that the lockdown of the city of Wuhan was officially announced by Chinese government.

Incubation Period

We list the sources that are utilized for estimating incubation period via meta-analysis in Table A2. In Linton et al. (2020), the authors adopted a variety of distributions for modeling the probability density function of incubation period, leading to slightly different results. We picked the confidence interval under the assumption of log-normal, referring to the best-fit model therein.

Serial Interval

We list the sources that are utilized for estimating incubation period via meta-analysis in Table A3. In Li et al. (2020a), serial interval estimates of different generations were given, where the estimate for the first generation was chosen for the present analysis.

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Table A1: Estimates and confidence intervals of R_0 for COVID-19 in China in the literature

	basis reproduction number			additional information	
Source	Estimate	95% L.B.	95% U.B.	Size	Study period
Cao et al. (2020)	4.08	3.37	4.77	618	12.16.2019–1.25.2020
Kucharski et al. (2020)	2.35	1.15	4.77	na	12.1.2019–2.11.2020
Li et al. (2020b)	2.20	1.40	3.90	425	12.29.2019–1.22.2020
Liu et al. (2020)	2.90	2.32	3.63	164	12.26.2019–1.23.2020
Imai et al. (2020)	2.60	1.50	3.50	4000	12.2.2019–1.18.2020
Read et al. (2020)	3.11	2.39	4.13	na	1.1.2020–1.22.2020
Read (2020)	5.70	3.80	8.90	140	1.15.2020–1.30.2020
Shen et al. (2020)	4.71	4.50	4.92	na	12.12.2019–1.22.2020
Sun et al. (2020)	2.94	2.38	3.50	na	1.23.2020–2.10.2020
Tian et al. (2020)	3.15	3.04	3.26	3156	1.23.2020–2.19.2020
Wu et al. (2020b)	2.68	2.47	2.86	5993	12.31.2019–1.28.2020
Zhu and Chen (2020)	2.69	2.61	2.77	na	12.1.2019–1.23.2020

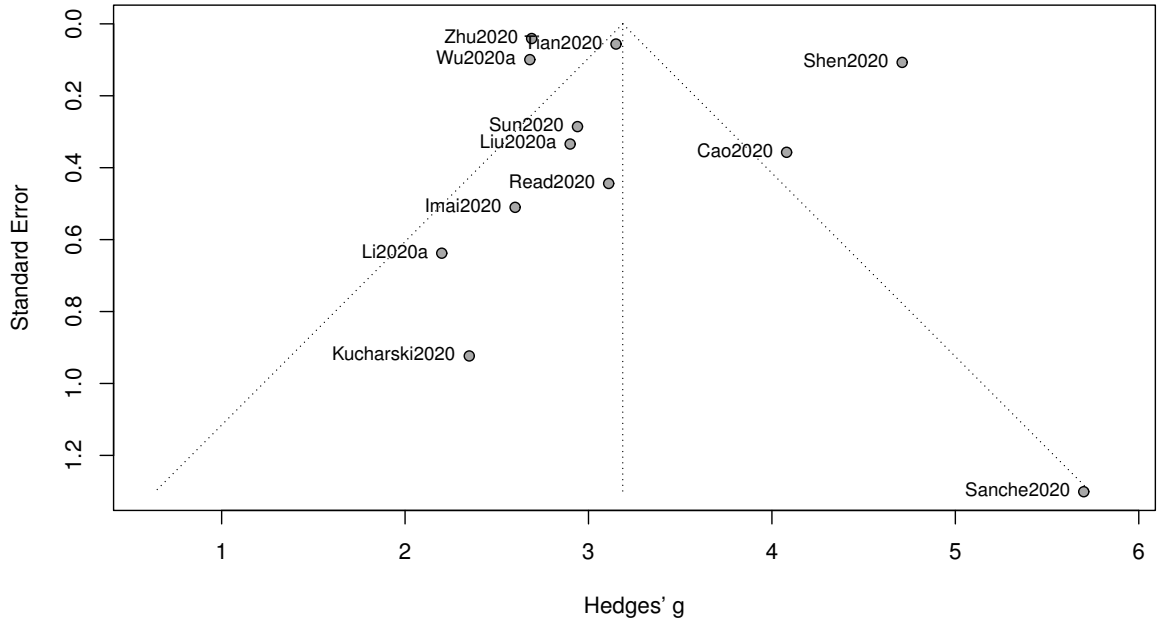

Figure S1: Funnel plot of meta-analysis for R_0

Epidemic Doubling Time

We list the sources that are utilized for estimating epidemic doubling time via meta-analysis in Table A4. In Lau et al. (2020), the authors reported two estimates of epidemic doubling time and associated confidence intervals, respectively before and after the implementation of lockdown in mainland China; we adopted the latter in the analysis. In Muniz-Rodriguez et al.

Table A2: Estimates and confidence intervals of incubation period of COVID-19 in China in the literature

	incubation period			additional information	
Source	Estimate	95% L.B.	95% U.B.	Size	Study period
Backer et al. (2020)	6.40	5.70	7.70	88	1.21.2020–1.28.2020
He et al. (2020)	2.30	0.80	3.00	94	1.21.2020–2.14.2020
Lauer et al. (2020)	5.10	4.50	5.80	181	1.4.2020–2.24.2020
Leung (2020)	6.90	5.50	8.30	152	1.20.2020-2.7.2020
Li et al. (2020b)	5.20	4.10	7.00	425	12.29.2019–1.22.2020
Linton et al. (2020)	5.00	4.40	5.60	276	1.1.2020–1.31.2020
Liu et al. (2020)	4.80	2.20	9.40	164	12.26.2019–1.23.2020
Han (2020)	5.84	2.91	8.75	59	12.29.2019–2.5.2020
Qin et al. (2020)	8.13	7.37	8.91	1922	1.19.2020–2.15.2020
Read (2020)	4.20	3.50	5.10	140	1.15.2020–1.30.2020
Xia et al. (2020)	4.90	4.40	5.40	106	1.3.2020 – 1.25.2020

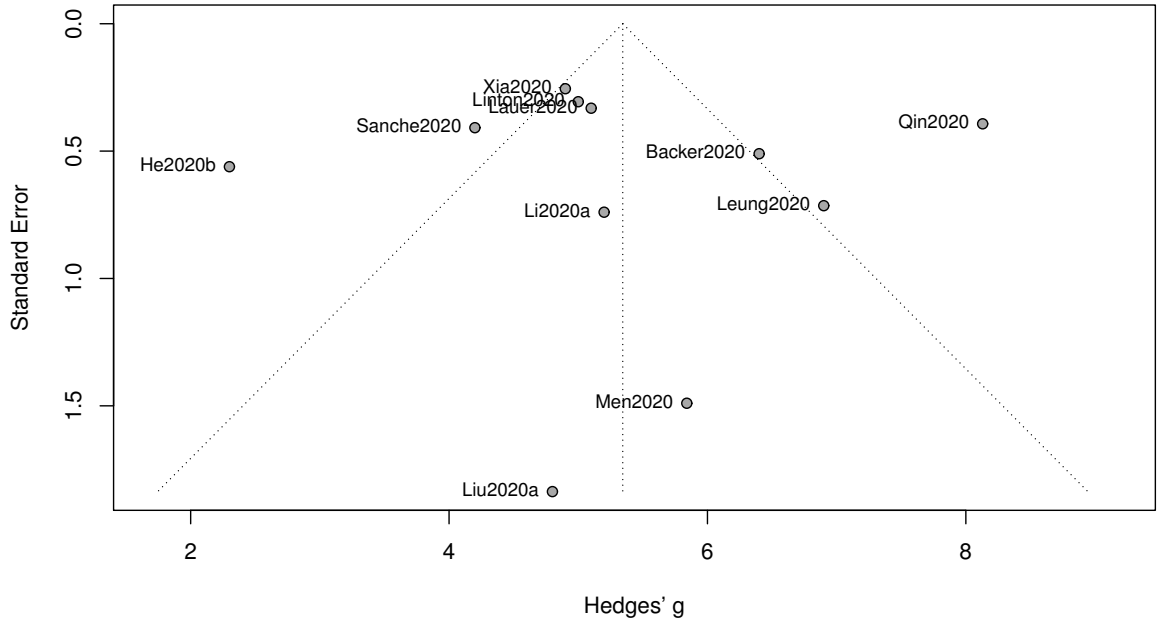

Figure S2: Funnel plot of meta-analysis for incubation period

(2020), the authors estimated epidemic doubling times for 31 provinces and municipalities in mainland China; we picked the one for "mainland China (except for Hubei province)" in our study.

Table A3: Estimates and confidence intervals of serial interval of COVID-19 in China in the literature

	serial interval			additional info.	
Source	Estimate	95% L.B.	95% U.B.	Size	Study period
Bi et al. (2020)	6.30	5.20	7.60	391	1.14.2020–2.12.2020
Du et al. (2020c)	3.96	3.53	4.39	486	1.21.2020–2.8.2020
Du et al. (2020b)	5.29	4.72	5.86	339	1.20.2020–2.19.2020
He et al. (2020)	5.20	4.10	6.40	94	1.21.2020–2.14.2020
Li et al. (2020b)	7.50	5.30	19.00	425	12.29.2019–1.22.2020
Li et al. (2020a)	6.27	5.62	6.98	337	1.21.2020–2.29.2020
Zhao et al. (2020b)	4.40	2.90	6.70	21	1.16.2020–2.15.2020
Tindale et al. (2020)	4.22	3.43	5.01	135	1.21.2020–2.22.2020
Wu et al. (2020a)	7.50	5.80	8.10	43	12.20.2019–2.10.2020
Zhang et al. (2020a)	5.10	1.30	11.60	35	1.19.2020–2.17.2020

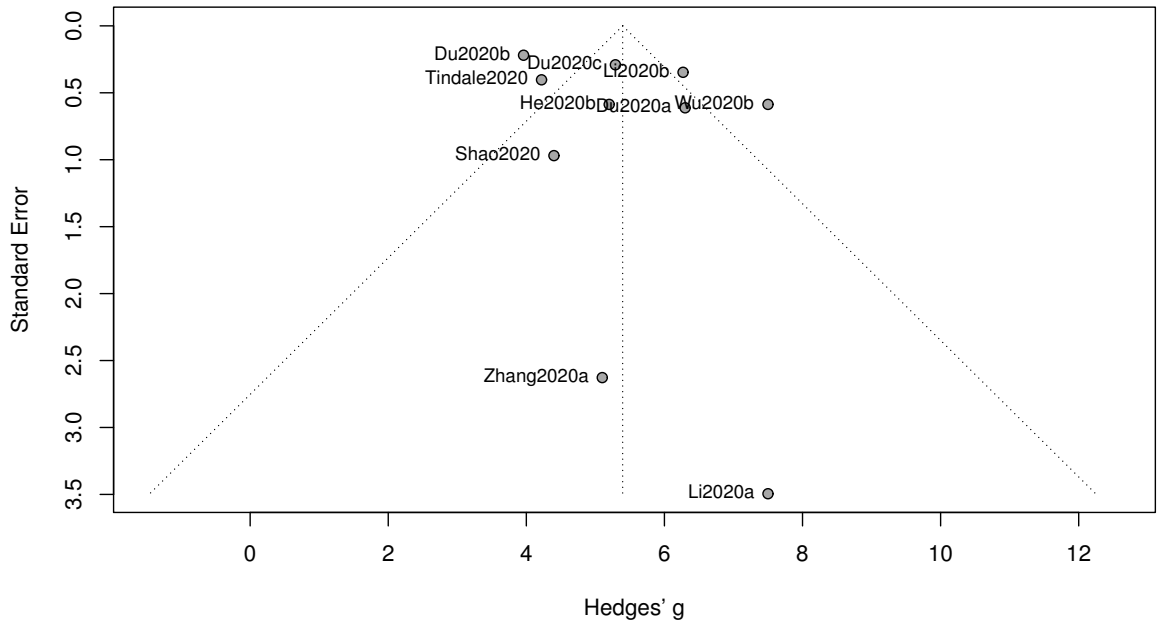

Figure S3: Funnel plot of meta-analysis for serial interval

Sensitivity Analysis

We list the sources that are utilized for estimating basic reproduction number in sensitivity analysis in Table A5. The additional studies include recent research in Japan, South Korea and Diamond Princess Cruise.

Table A4: Estimates and confidence intervals of epidemic doubling time of COVID-19 in China in the literature

	epidemic doubling time			additional information	
Source	Estimate	95% L.B.	95% U.B.	Size	Study period
Du et al. (2020a)	7.31	6.26	9.66	425	12.3.2019–1.24.2020
Kraemer et al. (2020)	4.00	3.60	5.00	554	1.1.2020–1.31.2020
Lau et al. (2020)	4.00	3.50	4.30	na	1.20.2020–2.13-2020
Li et al. (2020b)	7.10	3.00	20.50	425	12.29.2019–1.22.2020
Muniz-Rodriguez et al. (2020)	1.80	1.50	2.30	na	1.20.2020–2.19.2020
Volz et al. (2020)	6.60	4.00	12.70	53	12.8.2019–2.3.2020
Wu et al. (2020b)	6.40	5.80	7.10	5993	12.31.2019–1.28.2020
Wu et al. (2020a)	5.20	4.60	6.10	43	12.20.2019–2.10.2020

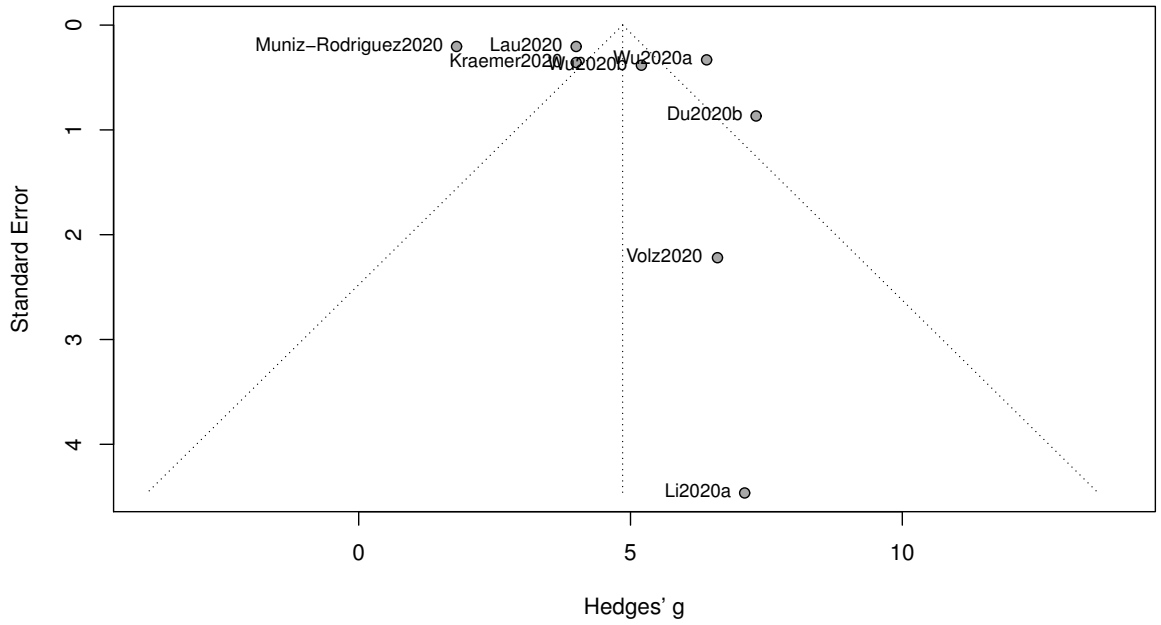

Figure S4: Funnel plot of meta-analysis for epidemic doubling time

References

Backer JA, Klinkenberg D, Wallinga J (2020). Incubation period of 2019 novel coronavirus (2019-nCoV) infections among travellers from Wuhan, China, 20–28 January 2020. *Eurosurveillance*, 25(5): 2000062.

Bi Q, Wu Y, Mei S, Ye C, Zou X, Zhang Z, et al. (2020). Epidemiology and transmission of COVID-19 in 391 cases and 1286 of their close contacts in Shenzhen, China: A retrospective cohort study. *The Lancet Infectious Diseases*. Forthcoming, https://doi.org/10.1016/

Table A5: Additional estimates and confidence intervals of basic reproduction number of COVID-19 for sensitivity analysis

		R_0		
Source	region	estimate	95% L.B.	95% U.B.
Kuniya (2020)	Japan	2.60	2.40	2.80
Sugishita et al. (2020)	Japan	1.99	1.89	2.09
Shim et al. (2020)	South Korea	1.50	1.40	1.60
Zhang et al. (2020b)	Diamond Princess Cruise	2.28	2.06	2.52
Zhao et al. (2020a)	Diamond Princess Cruise	2.20	2.10	2.40

S1473-3099(20)30287-5.

Cao Z, Zhang Q, Lu X, Pfeiffer D, Jia Z, Song H, et al. (2020). Estimating the effective reproduction number of the 2019-nCoV in China. MedRxiv preprint: https://doi.org/10.1101/2020.01.27.20018952.

Du Z, Wang L, Cauchemez S, Xu X, Wang X, Cowling BJ, et al. (2020a). Risk for transportation of coronavirus disease from Wuhan to other cities in China. *Emerging Infectious Diseases*, 26(5): 1049–1052.

Du Z, Wu Y, Wang L, Cowling BJ, Meyers LA, et al. (2020b). COVID-19 serial interval estimates based on confirmed cases in public reports from 86 chinese cities. MedRxiv preprint: https://doi.org/10.1101/2020.04.23.20075796.

Du Z, Xu X, Wu Y, Wang L, Cowling BJ, Meyers LA (2020c). Serial interval of COVID-19 among publicly reported confirmed cases. *Emerging Infectious Diseases*, 26(6): 1341.

Han H (2020). Estimate the incubation period of coronavirus 2019 (COVID-19). MedRxiv preprint: https://doi.org/10.1101/2020.02.24.20027474.

He X, Lau EH, Wu P, Deng X, Wang J, Hao X, et al. (2020). Temporal dynamics in viral shedding and transmissibility of COVID-19. *Nature Medicine*, 26(5): 672–675.

Imai N, Cori A, Dorigatti I, Baguelin M, Donnelly C, Riley S, et al. (2020). Report 3: Transmissibility of 2019-nCoV. http://hdl.handle.net/10044/1/77148.

Kraemer MU, Yang CH, Gutierrez B, Wu CH, Klein B, Pigott DM, et al. (2020). The effect of human mobility and control measures on the COVID-19 epidemic in China. *Science*, 368(6490): 493–497.

Kucharski AJ, Russell TW, Diamond C, Liu Y, Edmunds J, Funk S, et al. (2020). Early dynamics of transmission and control of COVID-19: A mathematical modelling study. *The Lancet Infectious Diseases*, 22: 553–558.

Kuniya T (2020). Prediction of the epidemic peak of coronavirus disease in Japan, 2020. *Journal of Clinical Medicine*, 9(3): 789.

Lau H, Khosrawipour V, Kocbach P, Mikolajczyk A, Schubert J, Bania J, et al. (2020). The positive impact of lockdown in Wuhan on containing the COVID-19 outbreak in China. *Journal of Travel Medicine*, 27(3): taaa037.

Lauer SA, Grantz KH, Bi Q, Jones FK, Zheng Q, Meredith HR, et al. (2020). The incubation period of coronavirus disease 2019 (COVID-19) from publicly reported confirmed cases: Estimation and application. *Annals of Internal Medicine*, 172(9): 577–582.

Leung C (2020). Estimating the distribution of the incubation period of 2019 novel coronavirus (COVID-19) infection between travelers to Hubei, China and non-travelers. MedRxiv preprint: https://doi.org/10.1101/2020.02.13.20022822.

Li M, Liu K, Song Y, Wang M, Wu J (2020a). Serial interval and generation interval for respectively the imported and local infectors estimated using reported contact-tracing data of COVID-19 in China. MedRxiv preprint: https://doi.org/10.1101/2020.04.15.20065946.

Li Q, Guan X, Wu P, Wang X, Zhou L, Tong Y, et al. (2020b). Early transmission dynamics in Wuhan, China, of novel coronavirus-infected pneumonia. *New England Journal of Medicine*, 382: 1199–1207.

Linton NM, Kobayashi T, Yang Y, Hayashi K, Akhmetzhanov AR, Jung Sm, et al. (2020). Incubation period and other epidemiological characteristics of 2019 novel coronavirus infections with right truncation: A statistical analysis of publicly available case data. *Journal of Clinical Medicine*, 9(2): 538.

Liu T, Hu J, Kang M, Lin L, Zhong H, Xiao J, et al. (2020). Transmission dynamics of 2019 novel coronavirus (2019-nCoV). BioRxiv preprint: https://doi.org/10.1101/2020.01.25.919787.

Muniz-Rodriguez K, Chowell G, Cheung CH, Jia D, Lai PY, Lee Y, et al. (2020). Doubling time of the COVID-19 epidemic by Chinese province. MedRxiv preprint: https://doi.org/10.1101/2020.02.05.20020750.

Qin J, You C, Lin Q, Hu T, Yu S, Zhou XH (2020). Estimation of incubation period distribution of COVID-19 using disease onset forward time: A novel cross-sectional and forward follow-up study. MedRxiv preprint: https://doi.org/10.1101/2020.03.06.20032417.

Read JM, Bridgen JR, Cummings DA, Ho A, Jewell CP (2020). Novel coronavirus 2019-nCoV: Early estimation of epidemiological parameters and epidemic predictions. MedRxiv preprint: https://doi.org/10.1101/2020.01.23.20018549.

Read MC (2020). EID: High contagiousness and rapid spread of severe acute respiratory syndrome coronavirus 2. *Emerging Infectious Diseases*, 26(7): 1470–1477.

Shen M, Peng Z, Xiao Y, Zhang L (2020). Modelling the epidemic trend of the 2019 novel coronavirus outbreak in China. BioRxiv preprint: https://doi.org/10.1101/2020.01.23.916726.

Shim E, Tariq A, Choi W, Lee Y, Chowell G (2020). Transmission potential and severity of COVID-19 in South Korea. *International Journal of Infectious Diseases*, 93: 339–344.

Sugishita Y, Kurita J, Sugawara T, Ohkusa Y (2020). Effect of voluntary event cancellation and school closure as countermeasures against COVID-19 outbreak in Japan. MedRxiv preprint: https://doi.org/10.1101/2020.03.19.20037945.

Sun H, Qiu Y, Yan H, Huang Y, Zhu Y, Chen SX (2020). Tracking and predicting COVID-19 epidemic in China mainland. MedRxiv preprint: https://doi.org/10.1101/2020.02.17.20024257.

Tian H, Liu Y, Li Y, Wu CH, Chen B, Kraemer MU, et al. (2020). An investigation of transmission control measures during the first 50 days of the COVID-19 epidemic in China. *Science*, 368(6491): 638–642.

Tindale L, Coombe M, Stockdale JE, Garlock E, Lau WYV, Saraswat M, et al. (2020). Transmission interval estimates suggest pre-symptomatic spread of COVID-19. MedRxiv preprint: https://doi.org/10.1101/2020.03.03.20029983.

Volz E, Baguelin M, Bhatia S, Boonyasiri A, Cori Z Aand Cucunubá, Cuomo-Dannenburg G, et al. (2020). Report 5: Phylogenetic analysis of SARS-CoV-2. https://spiral.imperial.ac.uk/handle/10044/1/77169.

Wu JT, Leung K, Bushman M, Kishore N, Niehus R, de Salazar PM, et al. (2020a). Estimating clinical severity of COVID-19 from the transmission dynamics in Wuhan, China. *Nature*

Medicine, 26(4): 506–510.

Wu JT, Leung K, Leung GM (2020b). Nowcasting and forecasting the potential domestic and international spread of the 2019-nCoV outbreak originating in Wuhan, China: A modelling study. *The Lancet*, 395(10225): 689–697.

Xia W, Liao J, Li C, Li Y, Qian X, Sun X, et al. (2020). Transmission of corona virus disease 2019 during the incubation period may lead to a quarantine loophole. MedRxiv preprint: https://doi.org/10.1101/2020.03.06.20031955.

Zhang J, Litvinova M, Wang W, Wang Y, Deng X, Chen X, et al. (2020a). Evolving epidemiology and transmission dynamics of coronavirus disease 2019 outside hubei province, China: A descriptive and modelling study. *The Lancet Infectious Diseases*, 20(7): 793–802.

Zhang S, Diao M, Yu W, Pei L, Lin Z, Chen D (2020b). Estimation of the reproductive number of novel coronavirus (COVID-19) and the probable outbreak size on the diamond princess cruise ship: A data-driven analysis. *International Journal of Infectious Diseases*, 93: 201–204.

Zhao S, Cao P, Gao D, Zhuang Z, Chong M, Cai Y, et al. (2020a). Modelling the coronavirus disease (COVID-19) outbreak on the diamond princess ship using the public surveillance data from january 20 to february 20, 2020. MedRxiv preprint: https://doi.org/10.1101/2020.02.26.20028449.

Zhao S, Gao D, Zhuang Z, Chong MK, Cai Y, Ran J, et al. (2020b). Estimating the serial interval of the novel coronavirus disease (COVID-19): A statistical analysis using the public data in hong kong from january 16 to february 15, 2020. MedRxiv preprint: https://doi.org/10.1101/2020.02.21.20026559.

Zhu Y, Chen YQ (2020). On a statistical transmission model in analysis of the early phase of COVID-19 outbreak. *Statistics in Biosciences*. Forthcoming, https://doi.org/10.1007/s12561-020-09277-0.