The basic reproduction number of novel coronavirus (2019-nCoV) estimation based on exponential growth in the early outbreak in China from 2019 to 2020: A reply to Dhungana

Shi Zhao

PII: S1201-9712(20)30083-7
DOI: https://doi.org/10.1016/j.ijid.2020.02.025
Reference: IJID 3971

To appear in: *International Journal of Infectious Diseases*

Qianyin Lin

PII: S1201-9712(20)30083-7
DOI: https://doi.org/10.1016/j.ijid.2020.02.025
Reference: IJID 3971

To appear in: *International Journal of Infectious Diseases*

Jinjun Ran

PII: S1201-9712(20)30083-7
DOI: https://doi.org/10.1016/j.ijid.2020.02.025
Reference: IJID 3971

To appear in: *International Journal of Infectious Diseases*

Salihu S Musa

PII: S1201-9712(20)30083-7
DOI: https://doi.org/10.1016/j.ijid.2020.02.025
Reference: IJID 3971

To appear in: *International Journal of Infectious Diseases*

Guangpu Yang

PII: S1201-9712(20)30083-7
DOI: https://doi.org/10.1016/j.ijid.2020.02.025
Reference: IJID 3971

To appear in: *International Journal of Infectious Diseases*

Weiming Wang

PII: S1201-9712(20)30083-7
DOI: https://doi.org/10.1016/j.ijid.2020.02.025
Reference: IJID 3971

To appear in: *International Journal of Infectious Diseases*

Yijun Lou

PII: S1201-9712(20)30083-7
DOI: https://doi.org/10.1016/j.ijid.2020.02.025
Reference: IJID 3971

To appear in: *International Journal of Infectious Diseases*

Daozhou Gao

PII: S1201-9712(20)30083-7
DOI: https://doi.org/10.1016/j.ijid.2020.02.025
Reference: IJID 3971

To appear in: *International Journal of Infectious Diseases*

Lin Yang

PII: S1201-9712(20)30083-7
DOI: https://doi.org/10.1016/j.ijid.2020.02.025
Reference: IJID 3971

To appear in: *International Journal of Infectious Diseases*

Daihai He

PII: S1201-9712(20)30083-7
DOI: https://doi.org/10.1016/j.ijid.2020.02.025
Reference: IJID 3971

To appear in: *International Journal of Infectious Diseases*

Maggie H Wang

PII: S1201-9712(20)30083-7

DOI: https://doi.org/10.1016/j.ijid.2020.02.025

Reference: IJID 3971

To appear in: *International Journal of Infectious Diseases*

Received Date: 12 February 2020

Please cite this article as: Zhao S, Lin Q, Ran J, Musa SS, Yang G, Wang W, Lou Y, Gao D, Yang L, He D, Wang MH, The basic reproduction number of novel coronavirus (2019-nCoV) estimation based on exponential growth in the early outbreak in China from 2019 to 2020: A reply to Dhungana, *International Journal of Infectious Diseases* (2020), doi: https://doi.org/10.1016/j.ijid.2020.02.025

The basic reproduction number of novel coronavirus (2019-nCoV) estimation based on exponential growth in the early outbreak in China from 2019 to 2020: A reply to Dhungana

Shi Zhao[1,2,*], Qianyin Lin[3], Jinjun Ran[4], Salihu S Musa[5], Guangpu Yang[6,7], Weiming Wang[8], Yijun Lou[5], Daozhou Gao[9], Lin Yang[10], Daihai He[5,*], and Maggie H Wang[1,2]

1 JC School of Public Health and Primary Care, Chinese University of Hong Kong, Hong Kong, China
2 Shenzhen Research Institute of Chinese University of Hong Kong, Shenzhen, China
3 Michigan Institute for Data Science, University of Michigan, Ann Arbor, Michigan, USA
4 School of Public Health, Li Ka Shing Faculty of Medicine, University of Hong Kong, Hong Kong, China
5 Department of Applied Mathematics, Hong Kong Polytechnic University, Hong Kong, China
6 Department of Orthopaedics and Traumatology, Chinese University of Hong Kong, Hong Kong, China
7 SH Ho Scoliosis Research Lab, Joint Scoliosis Research Center of Chinese University of Hong Kong and Nanjing University, Hong Kong, China
8 School of Mathematics and Statistics, Huaiyin Normal University, Huaian, China
9 Department of Mathematics, Shanghai Normal University, Shanghai, China
10 School of Nursing, Hong Kong Polytechnic University, Hong Kong, China

***** Correspondence to: zhaoshi.cmsa@gmail.com (SZ), and daihai.he@polyu.edu.hk (DH)

Email address of all authors
SZ: zhaoshi.cmsa@gmail.com
QL: qianying.lin@connect.polyu.hk
JR: jimran@connect.hku.hk
SSM: salihu-sabiu.musa@connect.polyu.hk
GY: kennethgpy@link.cuhk.edu.hk
WW: weimingwang2003@163.com
YL: yijun.lou@polyu.edu.hk
DG: dzgao@shnu.edu.cn
LY: l.yang@polyu.edu.hk
DH: daihai.he@polyu.edu.hk
MHW: maggiew@cuhk.edu.hk

Main text

To the editor

The ongoing outbreak of the novel coronavirus (2019-nCoV) pneumonia in Wuhan, China and other regions remains a major public health concern. We thank Dhungana's comments to our study, Zhao *et al*. [1], recently published in the International Journal of Infectious Diseases. The estimates on the basic reproduction number, R_0, were carried out in early outbreak as of January 22, 2020 when the surveillance data and the knowledge on the key epidemiological features of 2019-nCoV were limited.

The assumptions of exponential growth as well as other similar growing patterns are commonly accepted and adopted to capture the growing trends during the early phase of an outbreak [2-4]. The exponential growing rate (γ), or the intrinsic growing rate, is estimated from the early epidemic curve and used to calculate the R_0. We repeat the analysis in Zhao *et al*. [1], γ is estimated at 0.18 (95%CI: 0.14−0.22), 0.15 (95%CI: 0.12−0.18) and 0.11 (95%CI: 0.09−0.13) per day associated with 2-, 4- and 8-fold increase in the reporting rate, respectively. By using the serial interval (SI) estimate (mean ± SD at 7.5 ± 3.4 days) from Li *et al*. [5], we found the R_0 at 3.33 (95%CI: 2.17−4.04), 2.69 (95%CI: 2.28−3.17) and 2.13 (95%CI: 1.88−2.42) associated with 2-, 4- and 8-fold increase in the reporting respectively. Our estimates were in line with the WHO estimates in both early version (2-fold case) and the published version. The key message as we highlighted in the paper is the changes in reporting rate. This is recently reconfirmed by Tuite and Fishman [6]. We thank the editor and Dhungana to give us this opportunity to reclarify our key message that the reporting rate was not constant during the early outbreak and could affect the estimation of R_0. There is indeed a large amount of later confirmed cases which were not counted in the early official daily situation reports [5, 7-9]. In other words, if the same reporting standard in the second half of January was applied to the first half of January, the number of cases would be much higher. Other teams either used retrospective dataset which was not publicly available on January 23, 2020 or used oversea reported cases which was not (to a much less extent) affected by the changes in reporting rate.

By using the same analysis and dataset as in Zhao *et al*. [1], an additional sensitivity analysis on the R_0 estimates and varying SI and reporting rate was conducted and shown in Fig 1. We report that R_0 estimates increase while the mean of SI increases or the SD of SI decreases. By selecting mean between 7 and 8 days and SD between 3 and 4 days for SI of 2019-nCoV, the R_0 estimates are largely consistent within a range from 2 to 4 in many existing literatures [5, 7-10], see panels (f), (g), (j) and (k) Fig 1. We conclude that our previous estimation and main conclusions in [1] hold based on the reasonable selection of the SI estimates of 2019-nCoV. Not only our early version (2-fold case) is in line with the WHO estimates, but also we pointed out the issue in the reporting rate changes in the official reported cases.

Declarations

Ethics approval and consent to participate

The ethical approval or individual consent was not applicable.

Availability of data and materials

All data and materials used in this work were publicly available.

Consent for publication

Not applicable.

Funding

WW was supported by National Natural Science Foundation of China (Grant Number 61672013) and Huaian Key Laboratory for Infectious Diseases Control and Prevention (Grant Number HAP201704), Huaian, Jiangsu, China.

Disclaimer

The funding agencies had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; or decision to submit the manuscript for publication.

Conflict of Interests

The authors declared no competing interests.

Authors' Contributions

All authors conceived the study, carried out the analysis, discussed the results, drafted the first manuscript, critically read and revised the manuscript, and gave final approval for publication.

Acknowledgements

The authors thank Cindy Y Tian from the Chinese University of Hong Kong for helping on processing the reference files.

References

1. Zhao S, Lin Q, Ran J, Musa SS, Yang G, Wang W, Lou Y, Gao D, Yang L, He D *et al*: **Preliminary estimation of the basic reproduction number of novel coronavirus (2019-nCoV) in China, from 2019 to 2020: A data-driven analysis in the early phase of the outbreak**. *International Journal of Infectious Diseases* 2020.
2. Nishiura H, Chowell G: **Early transmission dynamics of Ebola virus disease (EVD), West Africa, March to August 2014**. *Eurosurveillance* 2014, **19**(36):20894.
3. Chowell G, Hengartner NW, Castillo-Chavez C, Fenimore PW, Hyman JM: **The basic reproductive number of Ebola and the effects of public health measures: the cases of Congo and Uganda**. *Journal of theoretical biology* 2004, **229**(1):119-126.
4. Wearing HJ, Rohani P, Keeling MJ: **Appropriate models for the management of infectious diseases**. *PLoS medicine* 2005, **2**(7):e174.
5. Li Q, Guan X, Wu P, Wang X, Zhou L, Tong Y, Ren R, Leung KSM, Lau EHY, Wong JY *et al*: **Early Transmission Dynamics in Wuhan, China, of Novel Coronavirus–Infected Pneumonia**. *New England Journal of Medicine* 2020.
6. Tuite AR, Fisman DN: **Reporting, Epidemic Growth, and Reproduction Numbers for the 2019 Novel Coronavirus (2019-nCoV) Epidemic**. *Annals of Internal Medicine* 2020.
7. Imai N, Dorigatti I, Cori A, Riley S, Ferguson NM: **Estimating the potential total number of novel Coronavirus (2019-nCoV) cases in Wuhan City, China**. *Preprint published by the Imperial College London* 2020:https://www.imperial.ac.uk/mrc-global-infectious-disease-analysis/news--wuhan-coronavirus/.
8. Riou J, Althaus CL: **Pattern of early human-to-human transmission of Wuhan 2019 novel coronavirus (2019-nCoV), December 2019 to January 2020**. *Eurosurveillance* 2020, **25**(4).
9. Zhao S, Musa SS, Lin Q, Ran J, Yang G, Wang W, Lou Y, Yang L, Gao D, He D *et al*: **Estimating the Unreported Number of Novel Coronavirus (2019-nCoV) Cases in China in the First Half of January 2020: A Data-Driven Modelling Analysis of the Early Outbreak**. *Journal of Clinical Medicine* 2020, **9**(2).
10. Wu JT, Leung K, Leung GM: **Nowcasting and forecasting the potential domestic and international spread of the 2019-nCoV outbreak originating in Wuhan, China: a modelling study**. *The Lancet* 2020.

Figure

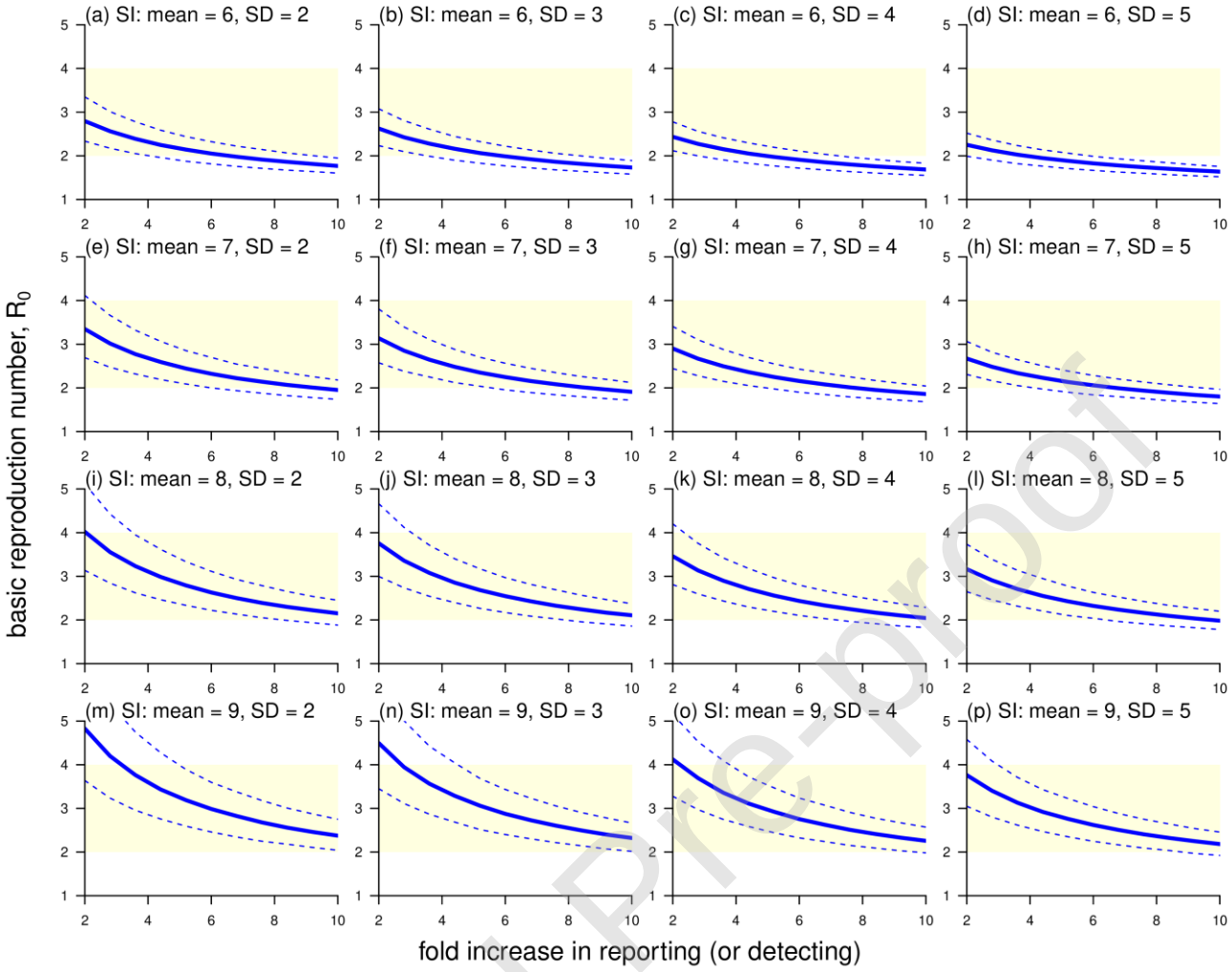

Figure 1

The estimates of the basic reproduction number, R_0, with varying reporting rates, mean and SD of serial interval (SI). The mean of SI, from top to bottom vertically, varies at 6, 7, 8 and 9 days. The SD of SI, from left to right horizontally, varies at 2, 3, 4 and 5 days. The light-yellow area highlights the R_0 ranging from 2 to 4 referring to the estimates in [5, 7-10]. The blue bold curve is the mean estimate, and the blue dashed curves are the 95% confidence interval (95%CI).