

Rapid Communication

The reproductive number of the Delta variant of SARS-CoV-2 is far higher compared to the ancestral SARS-CoV-2 virus

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SARS-CoV-2 variants of concerns (VOC) evolve in countries or areas with high virus circulation and low vaccine coverage rates. According to the World Health Organization, VOC are defined as virus variants for which there is evidence of an increase in transmissibility, more severe disease (e.g. increased hospitalizations or deaths), significant reduction in neutralization by antibodies generated during previous infection or vaccination, reduced effectiveness of treatments or vaccines, or diagnostic detection failures. The Alpha (B.1.1.7) variant emerged in the UK and was the first VOC to show higher transmissibility than the ancestral strain, rapidly becoming the dominating VOC from January 2021 onwards.¹ The Delta (B.1.617.2) variant emerged in India at a time of low vaccine coverage and high transmission rates and is now replacing all other SARS-CoV-2 variants, fuelling outbreaks in countries that had previously been able to suppress COVID-19 outbreaks and also causing resurgence in countries even with highly vaccinated populations.

In this study, we review the basic reproductive number (R_0) of the Delta variant contrasting it to the early estimates of R_0 of the ancestral strain from the pre-pandemic outbreak phase.² R_0 gives an indication of the epidemic potential of a virus, by representing the average number of new infections generated by an infectious person in a totally naïve population in the absence of effective control and vaccines. It basically transforms the contact rate and the transmissibility of an infectious pathogen into a threshold condition describing the longer-term prospects of the pathogen circulation. To put it simply, if $R_0 > 1$, the epidemic will grow, and if $R_0 < 1$, the epidemic will reverse.

We searched for eligible studies in PubMed, bioRxiv, medRxiv, Baidu, CNKI and Wanfang database covering the

period from 1 January 2020 to 30 July 2021, in both English and Chinese language. Given the novelty of this variant, we just used broad search terms which included (Delta) OR (B.1.617.2). We had 15 170 hits in PubMed, 1032 in MedRxiv and 13 286 through bioRxiv.

We identified five studies, which estimated the basic reproductive number for Delta. Table 1 shows that the basic reproductive number for Delta ranged from 3.2 to 8, with a mean of 5.08. Supplementary Figure S1 in Appendix displays the published R_0 estimates for the Delta variant and ancestral strain.

An R_0 of 5.08 is much higher than the R_0 of the ancestral strain with a R_0 of 2.79, which was the estimated median R_0 in Liu et al.'s review study based on 14 estimates of the ancestral strain.² With an R_0 of 5.08, Delta also has a much higher reproductive number compared to other viral infections such SARS, MERS, smallpox, Ebola, seasonal influenza and pandemic influenza.³ Delta infections are associated with higher viral loads and longer duration of shedding causing higher transmissibility and R_0 ^{4,5} and also lower vaccine effectiveness affecting the effective reproduction number impacted by disease control, R_e .⁶ Delta variant may possibly also cause more severe disease with higher odds of hospitalization, ICU admission and death.⁷

Given its high reproductive number associated with higher transmissibility, in a context of globally still, low vaccine coverage rates and lower vaccine effectiveness, public health and social measures will need to be substantially strengthened to combat this emerging variant, with more stringent measures required compared to the ancestral SARS-CoV-2 strains and other variants. A high reproductive number also means that much higher vaccine coverage rates need to be achieved

Table 1. Published estimates of R_0 for the Delta variant of SARS-CoV-2

First author (study reference)	Location	Study date	Methods	R_0 estimates	95% CI
Meng Zhang (Meng Zhang, Jianpeng Xiao, Aiping Deng, Yingtao Zhang, Yali Zhuang, Ting Hu, Jiansen Li, Hongwei Tu, Bosheng Li, Yan Zhou, Jun Yuan, Lei Luo, Zimian Liang, Youzhi Huang, Guoqiang Ye, Mingwei Cai, Gongli Li, Bo Yang, Bin Xu, Ximing Huang, Yazun Cui, Dongsheng Ren, Yanping Zhang, Min Kang, Yan Li. Transmission Dynamics of an Outbreak of the COVID-19 Delta Variant B.1.617.2—Guangdong Province, China, May–June 2021[J]. <i>China CDC Weekly</i> , 2021, 3(27): 584–586. doi: 10.46234/ccdcw2021.148)	Guangdong Province, China	May–June 2021	Maximum likelihood method	3.2	2.0–4.8
Qingfeng Shi (Qingfeng Shi, Xiaodong Gao, Bijie Hu. Research progress on characteristics, epidemiology and control measure of SARS-CoV-2 Delta VOC. <i>Chin J Nosocomiol</i> Vol.31, 2021)	Guangdong Province, China	After 21 May 2021	/	4.04–5.0	/
SPI-M-O (SPI-M-O: Summary of further modelling of easing restrictions—roadmap Step 4)	England	before 9 June, 2021	SPI-M-O's modelling	5–8	/
David Mackie (David Mackie, J.P. Morgan. Global vulnerabilities to the COVID-19 variant B.1.617.2. <i>SUERF Policy Briefs</i> No 110, June 2021)	UK	May 2021	Assuming the secondary attack rate of Delta excluding the impact of NPIs and vaccinations was around 4.29%	5.2	/
Hengcong Liu (Hengcong Liu, Juanjuan Zhang, Jun Cai, Xiaowei Deng, Cheng Peng, Xinghui Chen, Juan Yang, Qianhui Wu, Zhiyuan Chen, Wen Zheng, Cécile Viboud, Wenhong Zhang, Marco Ajelli, Hongjie Yu. Herd immunity induced by COVID-19 vaccination programs to suppress epidemics caused by SARS-CoV-2 wild type and variants in China. <i>medRxiv</i> 2021.07.23.21261013. 10.1101/2021.07.23.21261013) Averaged 5.08	China	July 2021	Based on the transmissibility of the Delta variant is 50% higher as compared with that of the Alpha variant	6	/

compared to the originally assumed 60–70% vaccine coverage for the ancestral strain. A reproductive number of 5 would mean that vaccine coverage rates above 80% will be needed based on the equation $q = 1 - 1/R_0$, assuming a 100% vaccine efficacy. However, with decreasing vaccine effectiveness associated with the Delta variant,⁶ vaccine coverage rates above 90% will need to be achieved to contain Delta outbreaks. Fortunately, vaccine effectiveness against severe disease remains relatively maintained, while mild-to-moderate breakthrough infections in vaccinated persons have increased as the result of the emergence of the Delta variant.

Given that the reproductive number in the studies identified here was estimated at a time when most countries still enforce a variable extent of lockdown measures, there is a risk that the real reproductive number may be even higher than the estimated 5.08.

Rapidly ramping up vaccine coverage rates globally while maintaining or enhancing public health and social measures⁸ is now even more urgent and important in the era of the Delta variant.

Supplementary data

Supplementary data are available at *JTM* online.

Author contributions

Y.L. did the literature search and created the table and figure. J.R. contributed to the data analysis and interpretation. Both authors contributed to the final manuscript.

Conflict of interest

None declared.

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