Changes in the serial interval and transmission dynamics associated with the SARS-CoV-2 Delta variant in South Korea

Authors:

Sukhyun Ryu[1,a], Dasom Kim[1,a], Jun-Sik Lim[2,a], Sheikh Taslim Ali[3,4], Benjamin J. Cowling[3,4]

Affiliations:

1. Department of Preventive Medicine, Konyang University College of Medicine, Daejeon, Republic of Korea
2. Graduate School of Public Health, Seoul National University, Seoul, South Korea
3. WHO Collaborating Centre for Infectious Disease Epidemiology and Control, School of Public Health, Li Ka Shing Faculty of Medicine, The University of Hong Kong, Hong Kong Special Administrative Region, China
4. Laboratory of Data Discovery for Health, Hong Kong Science and Technology Park, Hong Kong Special Administrative Region, China

[a]S.R, D.K, and J.S.L. contributed equally to this study.

Author for correspondence: Prof Sukhyun Ryu, Department of Preventive Medicine, Konyang University College of Medicine, R707, Myungok-Euihak Gwan, 158, Gwanjeodong-ro, Seogu, Daejeon, South Korea. 35365, Telephone: +82 42 600 8673; Email: gentryu@onehealth.or.kr

Keywords*:* COVID-19; delta variant; transmissibility; superspreading; Korea

Running head: Transmission dynamics of Delta variant

Abstract

We estimated the mean serial interval and superspreading potential for the Delta variant SARS-CoV-2. As the Delta variant increased in prevalence, the mean serial interval declined from 4.0 to 2.5 days. However, the risk of superspreading events was similar, as 25% to 27% of cases seeded 80% of all transmissions.

Main text

South Korea is in the middle of a fourth community epidemic of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) transmission, which is now predominated by the B.1.617.2 lineage (Delta variant) (1, 2). The transmissibility and epidemic size largely depend on epidemiological characteristics such as serial interval distribution and transmissibility (3, 4). However, for the Delta variant of SARS-CoV-2, empirical evidence produced using country-level data is limited. Here, we estimated serial interval distribution, reproductive numbers and superspreading potential.

The study

We obtained individual case data on COVID-19 cases reported by Korean local public health authorities. We examined data on 53,896 local cases from 11 July 2021 through 14 August 2021, when the Delta variant accounted for more than 40% of local cases as reported by the Korea Centers for Control and Prevention Agency (1, 2). The data included information on contact tracing with other reported cases of COVID-19 and the dates of symptom onset. Because the detection rate of the Delta variant accounted for more than 50% of local cases after 25 July 2021, we divided the study period into two periods (Period 1: 11

July 2021–24 July 2021 and Period 2: 25 July 2021–14 August 2021). The serial interval represents the time between symptom onset of successive cases in a transmission chain (3). We examined a subset of confirmed COVID-19 cases with symptom onset dates during our study period and reconstructed the transmission pairs by identifying the infector and infectee from the available information on the epidemiological links. Based on 3271 transmission pairs (out of a total 5063 pairs) having the date of symptom onset for both infector and infectee, the overall mean and standard deviation of the serial interval estimate were 3.22 days (95% Credible Interval [CrI]: 3.15, 3.30) and 4.38 days (95% CrI: 4.33, 4.44), respectively. The mean and standard deviation of the serial interval estimate during Period 1 and Period 2 were 3.95 days (95% CrI: 3.83, 4.07) with a standard deviation (SD) of 4.78 days (95% CrI: 4.70, 4.87), and 2.46 days (95% CrI: 2.37, 2.56) with an SD of 3.77 days (95% CrI: 3.70, 3.84), respectively (Figure 1A).

To identify the potential changes in Delta variant SARS-CoV-2 transmissibility, we estimated the time-varying effective reproductive number (R_t), which defines the mean number of secondary infectious cases generated from a typical primary infectious case at time t (Figure 1B and C). We estimated R_t using the EpiEstim package in R (5). Enhanced social distancing measures included limiting gathering sizes to 4 people nationwide were implemented from 19 July 2021 (6). However, we identified that the estimated R_t was sustained above 1 during the study period (Figure 1C).

For SSE analysis, we calculated the number of secondary cases for each individual from the transmission pairs and fitted the data into a negative binomial distribution (7) (Appendix). The two parameters of the distribution represent the reproduction number (R) and overdispersion parameter (k), respectively. The estimated k of Period 1 and Period 2 was 0.75 (95% CrI: 0.67, 0.85) and 1.01 (95% CrI: 0.87, 1.17), which corresponded to an expected proportion of cases responsible for 80% of secondary cases of 25% (95% CrI: 24%,

26%) and 27% (95% CrI: 26%, 28%) (Figure 2).

Conclusions

We estimated that the serial interval distribution of SARS-CoV-2 was shortened as the Delta was becoming predominant. This is consistent with other recent studies describing the faster spread of the Delta variant compared to other SARS-CoV-2 strains (8, 9). The changes in the implementation of public health measures such as contact tracing and isolation of COVID-19 patients would have affected the serial interval, transmissibility and superspreading potential (3, 4). However, the South Korean public health authority has consistently implemented strategies for active case finding and the immediate isolation of laboratory-confirmed COVID-19 patients and exposed individuals using digital QR codes since 10 June 2020 (10) (Appendix). Therefore, the impact of enhanced case isolation against the serial interval of SARS-CoV-2 is likely limited. Furthermore, restricting large gathering had likely reduced the superspreading potential. However, as the R_t was above 1 during most of the study period, this social distancing measure was insufficient to control the transmission of SARS-CoV-2.

Our study has some limitations. First, in our analysis, we did not consider the impact of COVID-19 vaccinations. Though only about 7% of transmission pairs used in this study were linked with older adults (≥ 65 years of age), who might have received COVID-19 vaccinations. The vaccination program has not yet been extended to the public below 55 years of age as of early August 2021. Second, we did not consider the increased amount of travel as the study period covered summer holidays. However, enhanced social distancing was consistently implemented nationwide during the study period. Third, we retrieved online case reports, which could have some inaccuracies in the information. However, the daily

number of laboratory-confirmed local cases was similar between the collected line list and official daily reports (Appendix).

Our findings suggest that the introduction of the Delta variant is likely to have increased the difficulty of controlling SARS-CoV-2 transmission in South Korea. The large number of COVID-19 cases in South Korea during the study period could be explained by faster and more intense transmission despite enhanced social distancing measures in place. Encouraging COVID-19 vaccination and further strengthening public health measures are warranted to mitigate the Delta variant of SARS-CoV-2.

Acknowledgments

This work was supported by the Basic Science Research Program through the National Research Foundation of Korea, funded by the Korean Ministry of Education (NRF-2020R1I1A3066471).

References

1. Cha S. South Korea reports record daily infections as Delta variant drives surge: Reuters; 2021.

2. Korea Centers for Disease Control and Prevention Agency. COVID-19 update as of 3 August 2021. 2021 [cited 2021 6 Aug]; Available from: https://www.korea.kr/news/policyBriefingView.do?newsId=156464695#sitemap-layer

3. Ali ST, Wang L, Lau EHY, Xu XK, Du Z, Wu Y, et al. Serial interval of SARS-CoV-2 was shortened over time by nonpharmaceutical interventions. Science. 2020 Aug 28;369(6507):1106-9.

4. Lim JS, Noh E, Shim E, Ryu S. Temporal Changes in the Risk of Superspreading

Events of Coronavirus Disease 2019. Open Forum Infect Dis. 2021 Jul;8(7):ofab350.

5. Thompson RN, Stockwin JE, van Gaalen RD, Polonsky JA, Kamvar ZN, Demarsh PA, et al. Improved inference of time-varying reproduction numbers during infectious disease outbreaks. Epidemics. 2019 Dec;29:100356.

6. Central Disaster and Safety Countermeasures Headquarters. Private gatherings are possible for up to 4 people. 2021 [cited 2021 17 August]; Available from: http://ncov.mohw.go.kr/tcmBoardView.do?brdId=&brdGubun=&dataGubun=&ncvContSeq=366501&contSeq=366501&board_id=&gubun=ALL

7. Lloyd-Smith JO, Schreiber SJ, Kopp PE, Getz WM. Superspreading and the effect of individual variation on disease emergence. Nature. 2005 Nov 17;438(7066):355-9.

8. Kang M, Xin H, Yuan J, Ali ST, Liang Z, Zhang J, et al. Transmission dynamics and epidemiological characteristics of Delta variant infections in China. medRxiv. 2021:2021.08.12.21261991.

9. Li B, Deng A, Li K, Hu Y, Li Z, Xiong Q, et al. Viral infection and transmission in a large, well-traced outbreak caused by the SARS-CoV-2 Delta variant. medRxiv. 2021:2021.07.07.21260122.

10. Yonhap New Agency. S. Korea to test QR codes at nightclubs, eateries, cinemas to contain virus. Seoul, South Korea: Yonhap New Agency; 2020.

FIGURE LEGEND

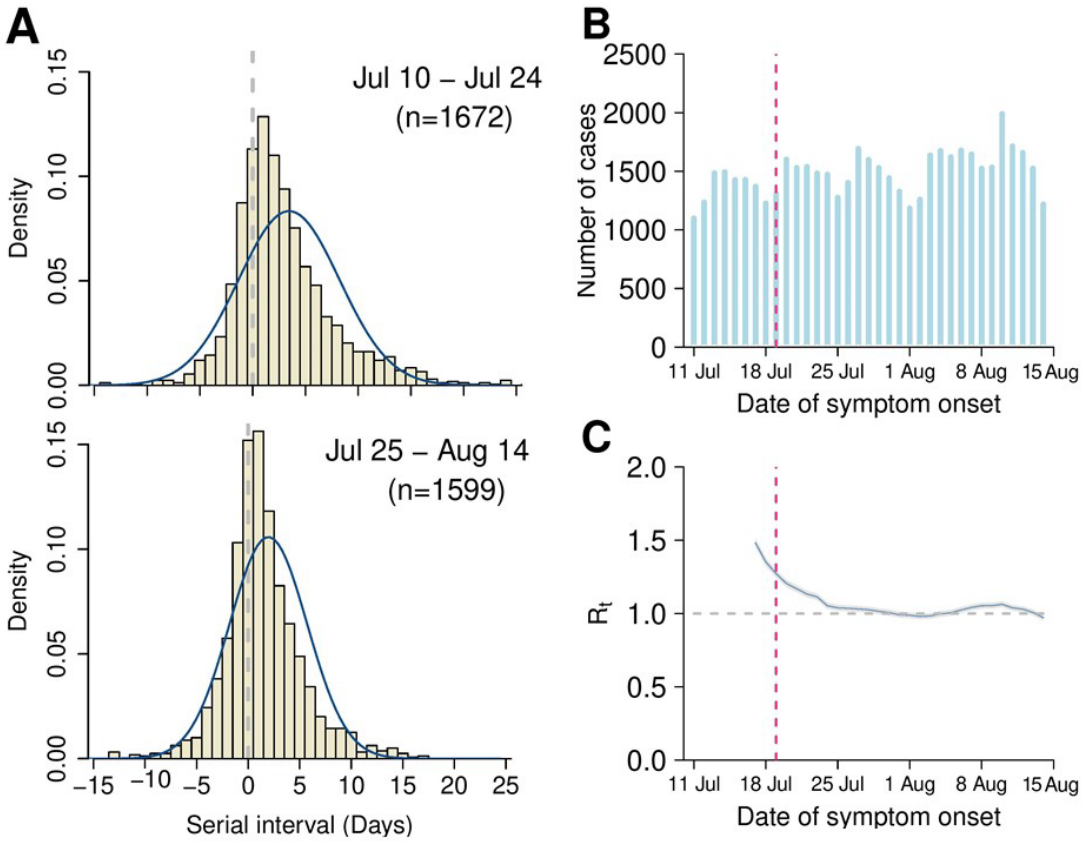

Figure 1. Estimated serial interval distribution, incidence of COVID-19 and transmissibility associated the Delta variant of SARS-CoV-2 in South Korea. A) The estimated serial interval distribution by using the 3271 infector-infectee pairs. The vertical bars indicate the distribution of empirical serial intervals, and the solid blue line indicates the fitted normal distribution. B) Reported number of confirmed COVID-19 cases by the date of symptom onset. The red vertical dashed line indicates the date of implementation of an enhanced social distancing including limiting gathering sizes to 4 people nationwide (19 July 2021). C) Estimated daily R_t of SARS-CoV-2 (blue line) with 95 credible intervals (gray shade). The gray horizontal dashed line indicates the critical threshold of R_t=1. The red vertical dashed line indicates the date of implementation of an enhanced social distancing. R_t=effective reproductive number

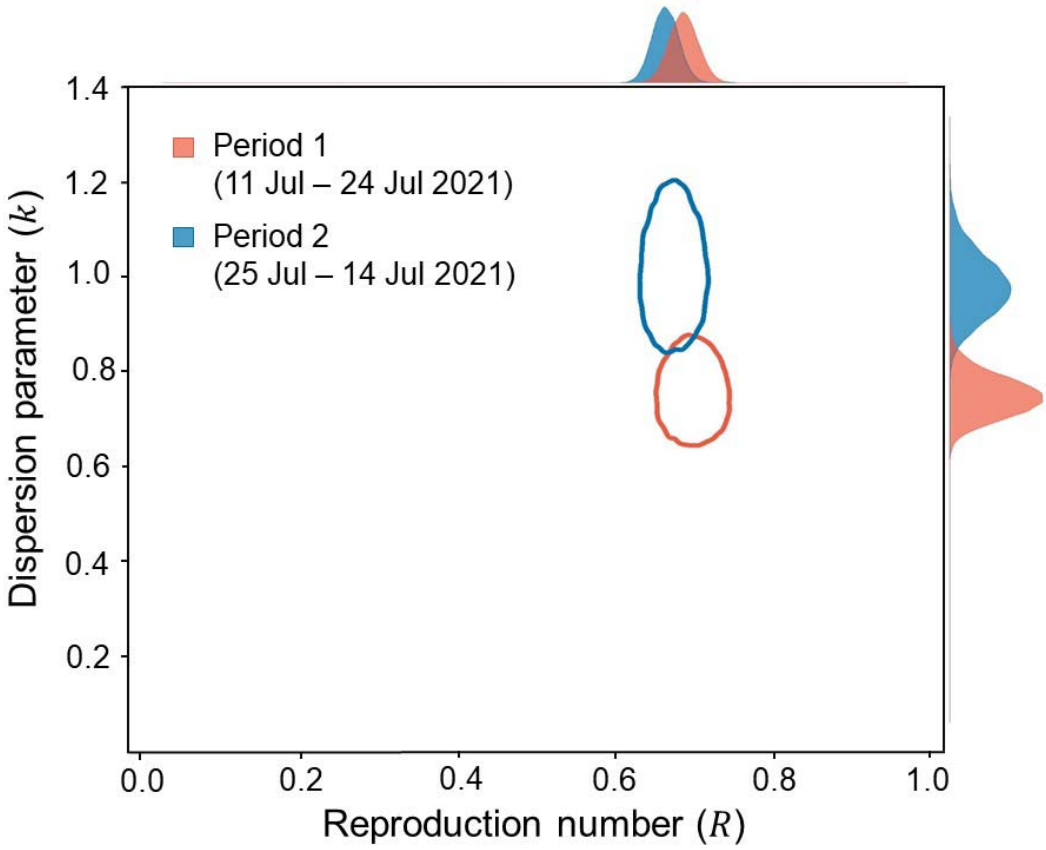

Figure 2. Risk of superspreading events for coronavirus disease 2019 (COVID-19) during the epidemic of SARS-CoV-2 lineage B.1.617 in July 2021 in South Korea. Joint estimates of the overdispersion parameter (k) and reproduction number (R) of COVID-19 by using 2715 pairs. The red and blue ovals indicate the bivariate 95% credible region of the estimated overdispersion parameter and reproduction number for Period-1 and Period-2. The posterior marginal distributions were plotted in red and blue shaded regions. Note: Period-1, 11 July 2021 – 24 July 2021; Period-2, 25 July 2021 – 14 August 2021.