Evidence brief of SARS-CoV-2 incubation periods

August 2021

Public Health Agency of Canada
Agence de la santé publique du Canada

Canada

TO PROMOTE AND PROTECT THE HEALTH OF CANADIANS THROUGH LEADERSHIP, PARTNERSHIP, INNOVATION AND ACTION IN PUBLIC HEALTH.

—Public Health Agency of Canada

Également disponible en français sous le titre :
Synthèse en bref sur les périodes d'incubation du SRAS-CoV-2

Suggested citation :

To obtain additional information, please contact:

Public Health Agency of Canada
Address Locator 0900C2
Ottawa, ON K1A 0K9
Tel.: 613-957-2991
Toll free: 1-866-225-0709
Fax: 613-941-5366
TTY: 1-800-465-7735
E-mail: publications-publications@hc-sc.gc.ca

Publication date: August 2021

Cat.: HP5-179/2024E-PDF
ISBN: 978-0-660-69539-6
Pub.: 230677

Table of Contents

Introduction

What is the incubation period for SARS-CoV-2 and has it changed with variants of concern (VOC)?

The incubation period is defined as the time between exposure to an infectious pathogen and symptom onset. The incubation period of SARS-CoV-2 determined by the World Health Organization (WHO) and the European Centers for Disease Control (ECDC) is 0-14.0 days, the US Centers for Disease Control and Prevention (CDC) is 2.0-14.0 days and the Public Health Agency of Canada is 1.0-14.0 days. A comparison across what was known on incubation periods for other coronaviruses reported the average incubation periods of SARS was 4.6 days (95% CI: 3.8-5.8 d) and MERS was 5.2 days (95% CI: 1.9-14.7 d)[1]. This review summarizes the incubation period of the original SARS-CoV-2 variants prior to the emergence of variants of concern (VOC) from several systematic reviews that included studies from the first 12 months of the pandemic (Table 2) and more recent research that has focused on establishing the incubation period of the VOCs (Table 1).

SARS-CoV-2 VOCs are circulating variants that have been flagged by national or global public health organizations. There are currently four VOCs: B.1.1.7 (Alpha), B.1.351 (Beta), P.1 (Gamma) and B.1.617.2 (Delta). VOCs are of concern when compared to the original SARS-CoV-2 variants, as their complement of mutations lead to increased transmissibility, increased virulence (morbidity or mortality), changes in clinical disease presentation, immune evasion, reduced effectiveness of treatments, vaccines and/or public health measures and/or are associated with diagnostic detection failures[2,3,4]. Canada has established a national definition for VOCs[3]. In May 2021, the WHO released a naming system for VOCs and variants of interest (VOIs) using Greek letters to improve the ease of communication on variants and potential stigma related to places where variants were first identified. This naming system has been adopted in this report[2].

This evidence brief focuses on the evidence up to August 17th, 2021 on incubation periods for SARS-CoV-2 and whether there is evidence that the incubation period for any VOC is different than previously circulating variants. In this summary, “original variant” refers to any variant that was not designated as a VOC or VOI.

Key points

Incubation period for the original SARS-CoV-2 variants (prior to VOCs)

Highlights from the current literature include:

- The incubation period of SARS-CoV-2 based on a range of estimates from meta-analyses of studies conducted in 2020 prior to the emergence of VOCs estimated pooled mean incubation periods of 4.9-6.9 days (9 meta-analyses) and pooled median incubation periods of 4.8-5.9 days (8 meta-analyses) (Table 2).
- The largest meta-analysis included 99 studies with a range of 2.33-17.60 days incubation period reported across studies and the pooled mean incubation period 6.38 days (95%CI 5.79-6.97) and median 5.41 days (95%CI 4.74-6.07) had high between study heterogeneity [5].
- In most meta-analyses the incubation period mean estimate is longer than the median estimate because there appears to be a few cases in each dataset with very long incubation periods, which causes a right skew in the data, also known as over dispersion in the tail of incubation periods. Long incubation periods are well documented particularly for immunocompromised populations, which have been covered in previous reviews and can be requested by contacting ocsoevidence-bcscdonneesprobantes@phac-apsc.gc.ca.
- Two reviews reported evidence of a longer incubation period in children compared to adults: median, 7.3 days in children vs. 5.8 days in adults [6], median 10 days vs. 7 days, respectively [7].
- The majority (up to 90%) of the studies included in the meta-analyses were from China and represented data collected in the first half of 2020[8, 9]. The incubation period estimated prior to the end of January 2020 was shorter than after January 2020 in these studies, which was hypothesized to represent a bias in the data as cases were increasing exponentially[9].
- The Canadian model estimating incubation period over the pandemic up to November 2020 reported a mean of 6.89 days, a median of 6 days and 90th, 95th, 99th percentiles of 11, 12, 13.5 days. The results suggested a slight increase in the incubation period over time [10].

Incubation period for VOCs

Highlights from the current literature include:

- Four studies were found on the incubation period for VOCs; one that looked at Alpha, two that looked at Delta, and one that looked at both Alpha and Delta (Table 1). No studies reporting on the incubation period for Beta or Gamma were found.
- The two studies included in this summary on Alpha incubation period found it could be shorter than original strains by 2 days. The first study is a small retrospective cohort study in Japan that reported incubation period of Alpha was shorter compared to other strains (mean: 3.53 days vs. 5.71 days / median 3.0 days vs. 5.0 days) [11]. The other was a surveillance report from England that

reported the median incubation period for Alpha was 4 days and no mean incubation period was provided [12]. Both results indicate that Alpha incubation period may be shorter, however there is low confidence in these estimates, which are likely to change as additional research is published.

- The three studies on Delta incubation period included two contact tracing investigations from Guangdong, China. All results indicated that Delta incubation period may be shorter, however the difference may not be significant and there is low confidence in these estimates, which are likely to change as additional research is published. The first study reported the mean incubation period was 5.8 days (95%CI 5.2-6.4) and the latent period was 4.0 days (95%CI 3.5-4.4) [13]. The latent period is defined as the time from acquiring infection to infectiousness onset. The other study estimated time to first positive PCR test, latent period rather than incubation period, in quarantined cases with Delta compared to a sample of cases from the initial epidemic wave in 2020: median 4 days (IQR 3-5) vs. 6 days (IQR 5-8), respectively[11]. The third estimate was a surveillance report from England that reported the median incubation period for Delta was 4 days[12]. Headings are used to help guide the reader through a document. They should be short, concise and descriptive. Heading levels should be organized by levels of subordination, and each section of the paper should start with the highest level of heading.

Overview of the evidence

Thirteen reviews on incubation periods prior to the emergence of VOCs were included in this review including systematic reviews and meta-analysis (n=9), meta-analyses (n=2), a rapid review (n=1), and a scoping review (n=1). In addition, one recently published primary research study and one quantitative model using Canadian data were included for information on pre-VOC incubation period estimates as they were not included in the 13 reviews (Table 2). Studies reporting on incubation period for any VOC were reported in four studies or reports (Table 1).

Most incubation period data comes from public health contact tracing investigations mainly from studies done in Asia. One study reported contact tracing surveillance data for VOCs in the UK. Contact tracing investigations are at high risk of bias due to their retrospective nature. The data may also be affected by the fact that people do not know with certainty when or where they were exposed. The systematic reviews were not evaluated by the AMSTAR-2, a tool for evaluating systematic reviews, however the methods synopsis indicates the missing steps of each systematic review. The quality of the reviews was highly variable in both conduct and reporting across reviews. The systematic reviews and meta-analyses that are included in this brief overlap with the

studies that were included. The quantitative model uses Canadian data to estimate the incubation period in the Canadian context. This model would be sensitive to the quality of the data used to develop the model.

The evidence for the non-VOC incubation period is abundant but not conclusive and the evidence for the VOC incubation period is sparse. This has resulted in large knowledge gaps on all SARS-CoV-2 viruses. Additional cohort studies are needed to assess early signals that the incubation period for original variants have evolved over time and to establish incubation periods for all the VOCs including pediatric studies to assess the early signal that children exposed to VOCs have a longer incubation period than adults.

Methods

A daily scan of the literature (published and pre-published) is conducted by the Emerging Science Group, PHAC. The scan has compiled COVID-19 literature since the beginning of the outbreak and is updated daily. Searches to retrieve relevant COVID-19 literature are conducted in Pubmed, Scopus, BioRxiv, MedRxiv, ArXiv, SSRN, Research Square and cross-referenced with the COVID-19 information centers run by Lancet, BMJ, Elsevier, Nature and Wiley. The daily summary and full scan results are maintained in a Refworks database and an excel list that can be searched. Targeted keyword searching was conducted within these repositories to identify relevant citations on COVID-19 and SARS-CoV-2. Search terms used included: (incubation period and (review or “variant of concern terms”)). This review contains research published up to August 17, 2021.

A Google search and search of targeted government websites was conducted to find publicly available reports, protocols and clinical data pertinent to the evidence questions. Search terms used included: COVID-19 and incubation period. Searches were conducted and websites accessed on August 17, 2021.

Each potentially relevant reference was examined to confirm it had relevant data, and relevant citations were explored for further detail; relevant data was extracted into the review.

Acknowledgments

Prepared by: Kusala Pussegoda and Lisa Waddell, National Microbiology Laboratory Emerging Science Group, Public Health Agency of Canada.

Editorial review, science to policy review, peer-review by a subject matter expert and knowledge mobilization of this document was coordinated by the Office of the Chief Science Officer: ocsoevidence-bcscdonneesprobantes@phac-aspc.gc.ca

Evidence tables

Table 1: Evidence of incubation period for VOCs (n=4): alpha (n=2), delta (n=3)

Study	Method	Key outcomes
Primary literature on alpha and delta		
Homma (2021)[11] Retrospective cohort study Japan Mar 2020-2021	A small retrospective cohort that included 30 Alpha cases from March 2021 and compared them to other SARS-CoV-2 strains from Mar 2020-Jan 2021.	• The reported incubation period of Alpha was shorter compared to other strains: mean 3.53 vs 5.71 days/ median 3.0 vs 5.0 days, respectively. • The incubation period for Alpha in close-contact environments was 0.62 times shorter than other strains (95% CI: 0.47, 0.82) after adjusting for age and sex.
Li (2021) [14] Preprint Outbreak investigation China June 2021	A study from China reported a shorter time interval between exposure and first PCR positive test in quarantined cases involved in an outbreak of Delta across the province of Guangdong (n=34) compared to cases caused by 19A/19B genetic strains during the early 2020 epidemic (n=29).	• Shorter time interval between exposure and first PCR positive test (latent period) in quarantined cases infected with Delta was a median 4 days (IQR 3-5) compared to a sample of traced cases from the initial epidemic wave in 2020, 6 days (IQR 5-8).
Kang (2021)[13] Preprint Outbreak investigation China May - June 2021	The transmission and epidemiological characteristics of the outbreak in Southern China is described. Analysis includes 167 cases of Delta in Guangdong.	• Mean estimate of the incubation period from 95 symptomatic cases was 5.8 days (95%CI 5.2-6.4) • The 95th percentile for Delta incubation cases was 11.5 days (95%CI 10.1-13.0) • Latent period was mean 4.0 days, (95%CI 3.5-4.4) • In this study, 73.9% of transmission occurred before symptom onset with peak

		infectiousness estimated at 2.1 days (95%CI 1.5-2.7) before symptom onset.
Public Health England (2021)[12] Report Surveillance data analysis UK Mar - May 2021	Contact tracing surveillance data from the UK between March 29 and June 9, 2021.	● For both household and non-household contacts the median incubation period was 4 days (estimated IQR from graph 2–7 days) for Delta and Alpha.

Abbreviations: CI, Confidence interval; IQR, Interquartile range; PCR, Polymerase Chain Reaction

Table 2: Estimates of incubation period for the original variants prior to the emergence of VOCs from systematic reviews (n=9), meta-analyses (n=2), rapid reviews (n=1) and scoping reviews (n=1) and select primary research not included in the syntheses (n=2)

Study	Method	Key outcomes
Reviews (n=13)		
Song (2021)[7] Systematic review NA Jun 2021	This systematic review conducted a search up to 10 March 2021 on COVID-19 family clusters. Eighteen studies (published Jan-May 2020) involving 34 children and 98 adults from 28 families were included. Incubation period was reported in 31 children and 72 adults. No risk of bias assessment conducted.	● The median (IQR) incubation period was longer in children 10 days (1–30) compared to adults 7 days (1–29) (p=0.045).
Elias (2021) [5] Short communication Meta-analysis Jan 2021	A systematic search was carried out on studies published from 1 January 2020 to 10 January 2021 reporting the SARS-CoV-2 incubation period. No studies on VOCs were identified. There is no systematic review protocol or risk of bias assessment reported. The meta-analysis included 99 studies, of which 23 (23.2%) were cohort studies, 61 (61.6%) were case series, and 15 (15.2%) were modeling studies. Results of meta-analysis available here.	● The mean incubation period was 6.38 days (95%CI 5.79-6.97, I^2=100%, 99 studies), range 2.33-17.60 days. ● The median incubation period was estimated at 5.41 days (95%CI 4.74- 6.07, I^2=95%, 99 studies). ● In the meta-regression, study design only explained 10% of the between study heterogeneity, the finding was the incubation period for cohort studies and predictive models was shorter than case series (p<0.01).
Li (2021)[15] Scoping review NA Apr 2021	This scoping review conducted a search up to 10 December 2020. There were 1920 confirmed cases included. Individual patient analysis was conducted by transforming case data to be double interval-censored, which was considered to be best for obtaining a precise estimate.	● The median incubation period was 4.8 days (4.6–5.0), with the 95th and 99th percentile of the distribution being 15.1 days (95%CI 14.4–15.7) and 22.9 days (95%CI 21.7–24.3).

	An accelerated failure time model was used to estimate the time to event distribution. This scoping review included a search, inclusion/exclusion criteria and data extraction and analysis. Thus, other than the omission of a risk of bias assessment resembles a systematic review more than a scoping review.	
Dhouib (2021)[8] Systematic review and meta-analysis NA Apr 2021	This systematic review was conducted with a search from December 2019 to December 1, 2020. Forty-two studies were included and consisted of 9 strong, 19 moderate, and 14 weak quality studies. The meta-analysis included 10 studies on mean incubation period. This systematic review has a registered protocol CRD42020196347, included a risk of bias and SIGN assessment of the certainty of the evidence. Random effects meta-analysis was conducted.	● The median incubation period ranged from 2-12 days with an IQR lower bound of 2 days and higher bound of 14 days (n=17 studies). The 95th percentile range was 10.3-16 days and the 99th percentile was up to 24 days. ● The mean incubation period ranged between 3.9-9.0 days (n=9 studies). The total incubation period ranged from 0-26 days. ● The pooled mean incubation period was 6.2 days (95% CI 5.4-7.0, I^2=77.1%, $p < 0.001$, 10 studies). Note included studies were from China (8), Singapore (1) and Argentina (1). Subgroup analysis revealed that heterogeneity was explained by study quality and method of calculation. ● One study reported the mean incubation period for children was 8 days (range 1-13).
Xin (2021)[9] Systematic review and meta-analysis NA Apr 2021	This systematic review included a search conducted from 1 February 2020 and 25 September 2020. The meta-analysis included 31 studies that reported mean incubation period and 41 studies that reported median incubation period. The search strategy is presented, articles were evaluated with the STROBE	● 62/72 studies were using data from China. The pooled median of the point estimates of the mean incubation period was 6.3 days (range: 1.8–9.1 days). ● The pooled estimate of mean incubation periods before the epidemic peak in China (January 2020) was 5.2 days (9 studies; 95%CI 4.8–5.7; I^2 = 56.5%), significantly lower than

	checklist for quality and a random effects meta-analyses and meta-regression were conducted.	the pooled estimate for studies conducted after the peak (March 2020) (18 studies; 7.2 days, 95%CI, 6.6–7.8; I^2 = 89.5%). ● The pooled median of the point estimates of the median incubation period were 5.4 days (range, 2.0–17.6 days). The median value is lower than the mean due to the right skew in the data. ● The 95th percentile of the incubation period was 11.0 days (5 studies; 95%CI 9.9–12.0; I^2=0.0%) before peak and 14.6 days (7 studies; 95%CI 13.7–15.5; I^2=66.9%) after peak of the outbreak in China. ● Analysis of incubation period data from China in Jan-May 2020 suggests that when cases were rising exponentially there was a bias towards shorter estimates.
Daley (2020)[16] Preprint Systematic Review NA Jul 2020	The systematic review search was conducted 18 July 2020 and included 21 studies reporting incubation period. There is no protocol, a brief search description, no risk of bias assessment and the statistical analysis was averaging.	● Across studies the mean 5.9 days and median 5.6 days were in agreement.
Alene (2021)[17] Systematic review and meta-analysis NA Mar 2021	This systematic review was conducted on studies published up to 30 June 2020. Search, screening and data extractions details provided. Risk of bias was assessed using the Ottawa-Newcastle Scale. Random effects meta-analysis included 14 studies on mean incubation period.	● The mean incubation period of COVID-19 ranged from 4.8-9 days. ● The weighted pooled mean incubation period of COVID-19 was 6.5 days (95%CI 5.9–7.1, I^2=97%, 14 studies, 1453 observations). ● 71.4% of the studies were assessed to be of good quality.
Wei (2020)[6] Preprint	The systematic review search was conducted up to 26 April 2020.	● Median incubation period of 5.8 days (95%CI 5.3-6.2, I^2=96.1%, p<0.0001) and mean 6.9 days.

Systematic review and meta-analysis NA Apr 2020	56 studies were included in the meta-analysis (4095 observations). Methods for the search, selection, data extraction and quality assessment (AHRQ) of studies are described. Random effects meta-analysis was conducted. Bayesian meta-analysis was also employed to better simulate the distribution of the incubation period. Meta-regression was used to explore heterogeneity.	● Incubation period was longer for asymptomatic cases (median, 7.7 days; 95%CI 6.3–9.4, p=0.0408) and children (median, 7.3 days; 95%CI 6.2–8.6, p =0.0219). ● A linear relationship between age and median incubation period was detected with a 16% increase for every 10 years age. ● An estimated 6.7% (95%CI 2.4–11.2%) and 1.4% (95%CI 0.1–3.6%) of infected people had incubation periods over 14 days and 21 days, respectively. ● The 97.5th percentile was 18 days incubation period for symptomatic cases, 14 days for asymptomatic and 25 days for children.
McAloon (2020)[18] Rapid review and meta-analysis NA Apr 2020	Rapid review and meta-analysis included a search conducted 8 April 2020. 24 studies were included for review, 9 of them were analyzed. The search, selection criteria, data extraction details and quality assessment using the Ottawa-Newcastle scale was described. Random effects meta-analysis was conducted.	● Mean incubation period was 5.8 days (95%CI 5.0-6.7) with uncertainty in the tail of the distribution. ● Median incubation period of 5.1 days (95%CI 4.5-5.8). ● The 95th percentile was 11.7 days (95%CI 9.7-14.2).
Quesada (2021)[19] Systematic review and meta-analysis NA Mar 2020	This systematic review was conducted with a search up to 21 March 2020. The meta-analysis included 7 studies. Search, selection strategies and meta-analysis methods are reported. Quality assessment was not done.	● The mean incubation period ranged from 5.6 (95%CI 5.2-6.0) to 6.7 days (95%CI 6.0-7.4), high heterogeneity (I^2 83.0%, p<0.001), depending on the statistical model used. ● A meta-regression of the 95th percentile data including mean age explained observed heterogeneity. For each 10 year increase in age, there was a 1 day increase in incubation period. Where the 95th percentile by mean age was

		10.5, 11.5 and 12.5 days for 40, 50 and 60 year old, respectively.
Khalili (2020)[20] Systematic review and meta-analysis NA Mar 2020	A systematic review was conducted up to 11 March 2020. 18 studies were included in the meta-analysis of incubation period, only 2 were from outside China. Search, selection strategies and meta-analysis methods are reported. Quality assessment was not done.	● The pooled mean incubation period was 5.68 (99% CI: 4.78-6.59) days, I^2= 98.4%.
Lauer (2020)[21] Meta-analysis NA Jan – Feb 2020	Pooled analysis of 181 cases reported Jan 4 – Feb 24, 2020 outside of Hubei province. The analysis in this paper is individual patient data meta-analysis. However the data was scraped from many different sources.	● Median incubation period was 5.1 days (95%CI 4.5-5.8 days). ● 97.5% of symptomatic cases developed symptoms within 11.5 days (95%CI 8.2-15.6 days). ● Authors reported that these estimates indicate that from 10,000 cases, 101 would develop symptoms after 14 days.
Lin (2020)[22] Systematic Review NA Jun 2020	Search date was Feb 21, 2020. 8 mathematical or statistical models that estimated incubation period were included. The search strategy, selection criteria and data extraction are described. The ISPOR-SMDM Modelling Good Research Practices Task Force tool was used to evaluate the models. Estimates are descriptively summarized.	● The median incubation was 5.90 days (IQR 4.78–6.25) across 9 studies.
Primary literature (n=1)		
Huang (2021)[23] Preprint Retrospective cohort China NR	787 cases from outside Wuhan with sufficient information about exposure and symptom onset were identified from a national database of cases during 2020 in China. An interval-censored data estimation methods was used to study the data and factors that may explain the variability in incubation period. A gamma	● The mean incubation period was 7.8 (7.4-8.5) days. ● Percentiles: ○ 50th (median), 7.0 (6.7~7.3) days ○ 75th 10.0 (9.7~10.4) days ○ 97.5th 17.9 (17.1~18.7) days ● Factors that may explain heterogeneity in incubation

	distribution best fit the data which was right skewed.	period estimates were analysed and the findings indicate longer incubation periods were associated with females, older people and those with mild disease.
Model (n=1)		
Paul (2021)[10] Model Canada Nov 2020	SEIR model of the Canadian epidemic was developed to estimate the incubation period up to Nov 2020.	● Estimates include a mean incubation period of 6.74 days (95%CI 6.35-7.13), a median of 6 days and 90th percentile of 11.64 days (95%CI 11.22-12.17), 95th percentile of 12 days and 99th percentile of 13.5 days. ● The model predicts a peak incubation period at 6 days with a second smaller peak at 10 days. ● This model also detected a slight increase over time in incubation period.

Abbreviations: CI, Confidence interval; IQR, Interquartile range; NA, country not applicable; NR, Not reported

References

1. Wang Y, Wang Y, Chen Y, et al. Unique epidemiological and clinical features of the emerging 2019 novel coronavirus pneumonia (COVID-19) implicate special control measures. J Med Virol. 2020 03/05:10.1002/jmv.25748. DOI:10.1002/jmv.25748.
2. World Health Organization (WHO). COVID Weekly epidemiological update [Internet]. Available from: https://www.who.int/publications/m/item/weekly-epidemiological-update---23-february-2021
3. Public Health Agency of Canada. SARS-CoV-2 variants: National definitions, classifications and public health actions [Internet]. URL: https://www.canada.ca/en/public-health/services/diseases/2019-novel-coronavirus-infection/health-professionals/testing-diagnosing-case-reporting/sars-cov-2-variants-national-definitions-classifications-public-health-actions.html.
4. World Health Organization. Tracking SARS-CoV-2 variants [Internet]. URL: https://www.who.int/en/activities/tracking-SARS-CoV-2-variants/.
5. Elias C, Sekri A, Leblanc P, et al. Incubation period of COVID-19: A meta-analysis. Int J Infect Dis. 2021 Feb 3 DOI:10.1016/j.ijid.2021.01.069.
6. Wei Y, Wei L, Liu Y, et al. A systematic review and meta-analysis reveals long and dispersive incubation period of COVID-19. medRxiv. 2020:2020.06.20.20134387. DOI:10.1101/2020.06.20.20134387.

7. Song WL, Zou N, Guan WH, et al. Clinical characteristics of COVID-19 in family clusters: A systematic review. World J Pediatr. 2021 Jun 25 DOI:10.1007/s12519-021-00434-z.
8. Dhouib W, Maatoug J, Ayouni I, et al. The incubation period during the pandemic of COVID-19: A systematic review and meta-analysis. Syst Rev. 2021 Apr 8;10(1):101. DOI:10.1186/s13643-021-01648-y.
9. Xin H, Wong JY, Murphy C, et al. The incubation period distribution of coronavirus disease 2019 (COVID-19): A systematic review and meta-analysis. Clin Infect Dis. 2021 Jun 12 DOI:10.1093/cid/ciab501.
10. Paul S, Lorin E. Distribution of incubation periods of COVID-19 in the canadian context. Sci Rep. 2021 Jun 15;11(1):12569. DOI:10.1038/s41598-021-91834-8.
11. Homma Y, Katsuta T, Oka H, et al. The incubation period of the SARS-CoV-2 B.1.1.7 variant is shorter than that of other strains. J Infect. 2021 Jun 16 DOI:10.1016/j.jinf.2021.06.011.
12. Public Health England. SARS-CoV-2 variants of concern and variants under investigation in England; Technical briefing 15 . England: Public Health England; 2021. Report No.: Jun 11, 2021 Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/993879/Variants_of_Concern_VOC_Technical_Briefing_15.pdf
13. Kang M, Xin H, Yuan J, et al. Transmission dynamics and epidemiological characteristics of delta variant infections in china. medRxiv. 2021:2021.08.12.21261991. DOI:10.1101/2021.08.12.21261991.
14. Li B, Deng A, Li K, et al. Viral infection and transmission in a large well-traced outbreak caused by the delta SARS-CoV-2 variant. medRxiv. 2021:2021.07.07.21260122. DOI:10.1101/2021.07.07.21260122.
15. Li ZY, Zhang Y, Peng LQ, et al. Demand for longer quarantine period among common and uncommon COVID-19 infections: A scoping review. Infect Dis Poverty. 2021 Apr 26;10(1):56. DOI:10.1186/s40249-021-00847-y.
16. Daley C, Fydenkevez M, Ackerman-Morris S. A systematic review of the incubation period of SARS-CoV-2: The effects of age, biological sex, and location on incubation period. medRxiv. 2020:2020.12.23.20248790. DOI:10.1101/2020.12.23.20248790.
17. Alene M, Yismaw L, Assemie MA, et al. Serial interval and incubation period of COVID-19: A systematic review and meta-analysis. BMC Infect Dis. 2021 Mar 11;21(1):257. DOI:10.1186/s12879-021-05950-x.
18. McAloon C, Collins Á, Hunt K, et al. Incubation period of COVID-19: A rapid systematic review and meta-analysis of observational research. BMJ Open. 2020 Aug 16;10:e039652. DOI:10.1136/bmjopen-2020-039652.
19. Quesada JA, López-Pineda A, Gil-Guillén VF, et al. Incubation period of COVID-19: A systematic review and meta-analysis. Rev Clin Esp. 2020 DOI:10.1016/j.rce.2020.08.005.
20. Khalili M, Karamouzian M, Nasiri N, et al. Epidemiological characteristics of COVID-19: A systematic review and meta-analysis. Epidemiol Infect. 2020 Jun 29:1-39. DOI:10.1017/s0950268820001430.

21. Lauer SA, Grantz KH, Bi Q, et al. The incubation period of coronavirus disease 2019 (COVID-19) from publicly reported confirmed cases: Estimation and application. Ann Intern Med. 2020 03/10:10.7326/M20-0504. DOI:10.7326/M20-0504.
22. Lin YF, Duan Q, Zhou Y, et al. Spread and impact of COVID-19 in china: A systematic review and synthesis of predictions from transmission-dynamic models. Frontiers in Medicine. 2020;7:1-11. DOI:10.3389/fmed.2020.00321.
23. Huang S, Li J, Dai C, et al. Incubation period of coronavirus disease 2019: New implications for intervention and control. Int J Environ Health Res. 2021 Apr 4:1-9. DOI:10.1080/09603123.2021.1905781.