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Coronavirus Disease 2019 (COVID-19)

13-16 minutes

Table 1. Parameter Values that vary among the five COVID-19 Pandemic Planning Scenarios. The scenarios are intended to advance public health preparedness and planning. They are **not** predictions or estimates of the expected impact of COVID-19. The parameter values in each scenario will be updated and augmented over time, as we learn more about the epidemiology of COVID-19. Additional parameter values might be added in the future (e.g., population density, household transmission, and/or race and ethnicity).

Parameter	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5: Current Best Estimate
R_0*	2.0		4.0		2.5
Infection Fatality Ratio†	0-19 years: 0.00002 20-49 years: 0.00007 50-69 years: 0.0025 70+ years: 0.028		0-19 years: 0.0001 20-49 years: 0.0003 50-69 years: 0.010 70+ years: 0.093		0-19 years: 0.00003 20-49 years: 0.0002 50-69

Parameter	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5: Current Best Estimate
					years: 0.005 70+ years: 0.054
Percent of infections that are asymptomatic§	10%	70%	10%	70%	40%
Infectiousness of asymptomatic individuals relative to symptomatic¶	25%	100%	25%	100%	75%
Percentage of transmission occurring prior to symptom onset**	30%	70%	30%	70%	50%

*The best estimate representative of the point estimates of R_0 from the following sources:
Chinazzi M, Davis JT, Ajelli M, et al. The effect of travel restrictions on the spread of the 2019 novel coronavirus (COVID-19) outbreak. *Science*. 2020;368(6489):395-400; Imai N.,

Cori, A., Dorigatti, I., Baguelin, M., Donnelly, C. A., Riley, S., Ferguson, N.M. (2020). Report 3: Transmissibility of 2019-nCoV. *Online report*

Li Q, Guan X, Wu P, et al. Early Transmission Dynamics in Wuhan, China, of Novel Coronavirus-Infected Pneumonia. *N Engl J Med*. 2020;382(13):1199-1207

Munayco CV, Tariq A, Rothenberg R, et al. Early transmission dynamics of COVID-19 in a southern hemisphere setting: Lima-Peru: February 29th-March 30th, 2020 [published online ahead of print, 2020 May 12]. *Infect Dis Model*. 2020; 5:338-345

Salje H, Tran Kiem C, Lefrancq N, et al. Estimating the burden of SARS-CoV-2 in France [published online ahead of print, 2020 May 13] [published correction appears in Science. 2020 Jun 26;368(6498):]. *Science*. 2020;eabc3517.

The range of estimates for Scenarios 1-4 represent the upper and lower bound of the widest confidence interval estimates reported in: Li Q, Guan X, Wu P, et al. Early Transmission Dynamics in Wuhan, China, of Novel Coronavirus-Infected Pneumonia. *N Engl J Med*. 2020;382(13):1199-1207.

Substantial uncertainty remains around the R_0 estimate. Notably, Sanche S, Lin YT, Xu C, Romero-Severson E, Hengartner N, Ke R. High Contagiousness and Rapid Spread of Severe Acute Respiratory Syndrome Coronavirus 2. *Emerg Infect Dis*. 2020;26(7):1470-1477 (https://dx.doi.org/10.3201/eid2607.200282) estimated a median R_0 value of 5.7 in Wuhan, China. In an analysis of 8 Europe countries and the US, the same group estimated R_0 of between 4.0 and 7.1 in the pre-print manuscript: Ke R., Sanche S., Romero-Severson, & E., Hengartner, N. (2020). Fast spread of COVID-19 in Europe and the US suggests the necessity of early, strong and comprehensive interventions. *medRxiv.*

† These estimates are based on age-specific estimates of

infection fatality ratios from Hauser, A., Counotte, M.J., Margossian, C.C., Konstantinoudis, G., Low, N., Althaus, C.L. and Riou, J., 2020. Estimation of SARS-CoV-2 mortality during the early stages of an epidemic: a modeling study in Hubei, China, and six regions in Europe. *PLoS medicine*, *17*(7), p.e1003189. Hauser et al. produced estimates of IFR for 10-year age bands from 0 to 80+ year old for 6 regions in Europe. Estimates exclude infection fatality ratios from Hubei, China, because we assumed infection and case ascertainment from the 6 European regions are more likely to reflect ascertainment in the U.S. To obtain the best estimate values, the point estimates of IFR by age were averaged to broader age groups for each of the 6 European regions using weights based on the age distribution of reported cases from COVID-19 Case Surveillance Public Use Data (https://data.cdc.gov/Case-Surveillance/COVID-19-Case-Surveillance-Public-Use-Data/vbim-akqf). The estimates for persons ≥70 years old presented here do not include persons ≥80 years old as IFR estimates from Hauser et al., assumed that 100% of infections among persons ≥80 years old were reported. The consolidated age estimates were then averaged across the 6 European regions. The lower bound estimate is the lowest, non-zero point estimate across the six regions, while the upper bound is the highest point estimate across the six regions.

§ The percent of cases that are asymptomatic, i.e. never experience symptoms, remains uncertain. Longitudinal testing of individuals is required to accurately detect the absence of symptoms for the full period of infectiousness. Current peer-reviewed and preprint studies vary widely in follow-up times for re-testing, or do not include re-testing of cases. Additionally, studies vary in the definition of a symptomatic case, which makes it difficult to make direct comparisons between estimates. Furthermore, the percent of cases that are asymptomatic may

vary by age, and the age groups reported in studies vary. Given these limitations, the range of estimates for Scenarios 1-4 is wide. The lower bound estimate approximates the lower 95% confidence interval bound estimated from: Byambasuren, O., Cardona, M., Bell, K., Clark, J., McLaws, M. L., & Glasziou, P. (2020). Estimating the extent of true asymptomatic COVID-19 and its potential for community transmission: systematic review and meta-analysis. *Available at SSRN 3586675*. The upper bound estimate approximates the upper 95% confidence interval bound estimated from: Poletti, P., Tirani, M., Cereda, D., Trentini, F., Guzzetta, G., Sabatino, G., Marziano, V., Castrofino, A., Grosso, F., Del Castillo, G. and Piccarreta, R. (2020). Probability of symptoms and critical disease after SARS-CoV-2 infection. *arXiv preprint arXiv:2006.08471*. The best estimate is the midpoint of this range and aligns with estimates from: Oran DP, Topol EJ. Prevalence of Asymptomatic SARS-CoV-2 Infection: A Narrative Review [published online ahead of print, 2020 Jun 3]. *Ann Intern Med*. 2020; M20-3012.

¶ The current best estimate is based on multiple assumptions. The relative infectiousness of asymptomatic cases to symptomatic cases remains highly uncertain, as asymptomatic cases are difficult to identify, and transmission is difficult to observe and quantify. The estimates for relative infectiousness are assumptions based on studies of viral shedding dynamics. The upper bound of this estimate reflects studies that have shown similar durations and amounts of viral shedding between symptomatic and asymptomatic cases: Lee, S., Kim, T., Lee, E., Lee, C., Kim, H., Rhee, H., Park, S.Y., Son, H.J., Yu, S., Park, J.W. and Choo, E.J., Clinical Course and Molecular Viral Shedding Among Asymptomatic and Symptomatic Patients With SARS-CoV-2 Infection in a Community Treatment Center in the Republic of Korea. *JAMA Internal Medicine*; Zou L, Ruan F,

Huang M, et al. SARS-CoV-2 Viral Load in Upper Respiratory Specimens of Infected Patients. *N Engl J Med*. 2020;382(12):1177-1179; and Zhou R, Li F, Chen F, et al. Viral dynamics in asymptomatic patients with COVID-19. *Int J Infect Dis*. 2020; 96:288-290. The lower bound of this estimate reflects data indicating that viral loads are higher in severe cases relative to mild cases (Liu Y, Yan LM, Wan L, et al. Viral dynamics in mild and severe cases of COVID-19. *Lancet Infect Dis*. 2020;20(6):656-657) and data showing that viral loads and shedding durations are higher among symptomatic cases relative to asymptomatic cases (Noh JY, Yoon JG, Seong H, et al. Asymptomatic infection and atypical manifestations of COVID-19: Comparison of viral shedding duration [published online ahead of print, 2020 May 21]. *J Infect*. 2020; S0163-4453(20)30310-8).

** The lower bound of this parameter is approximated from the lower 95% confidence interval bound from: He, X., Lau, E.H., Wu, P., Deng, X., Wang, J., Hao, X., Lau, Y.C., Wong, J.Y., Guan, Y., Tan, X. and Mo, X. (2020). Temporal dynamics in viral shedding and transmissibility of COVID-19. *Nature medicine*, *26*(5), pp.672-675. The upper bound of this parameter is approximated from the higher estimates of individual studies included in: Casey, M., Griffin, J., McAloon, C.G., Byrne, A.W., Madden, J.M., McEvoy, D., Collins, A.B., Hunt, K., Barber, A., Butler, F. and Lane, E.A. (2020). Estimating pre-symptomatic transmission of COVID-19: a secondary analysis using published data. *medRxiv.*The best estimate is the geometric mean of the point estimates from these two studies.

Table 2. Parameter Values Common to the Five COVID-19 Pandemic Planning Scenarios. The parameter values are likely to change as we obtain additional data about disease severity and viral transmissibility of COVID-19.

Parameter values are based on data received by CDC through August 8, 2020, including COVID-19 Case Surveillance Public Use Data (https://data.cdc.gov/Case-Surveillance/COVID-19-Case-Surveillance-Public-Use-Data/vbim-akqf); data from the Hospitalization Surveillance Network (COVID-NET) (through August 1); and data from Data Collation and Integration for Public Health Event Response (*DCIPHER*).

Pre-existing immunity Assumption, ASPR and CDC	No pre-existing immunity before the pandemic began in 2019. It is assumed that all members of the U.S. population were susceptible to infection prior to the pandemic.
Time from exposure to symptom onset*	~6 days (mean)
Time from symptom onset in an individual and symptom onset of a second person infected by that individual†	~6 days (mean)
Mean ratio of estimated infections to reported case counts, Overall (range)§	11 (6, 24)
Parameter Values Related to Healthcare Usage	
Median number of days from symptom onset to SARS-CoV-2 test among SARS-CoV-2 positive patients	Overall: 3 (1, 6) days

(interquartile range)[¶]	
Median number of days from symptom onset to hospitalization (interquartile range)[**]	18-49 years: 6 (3, 10) days 50-64 years: 6 (2, 10) days ≥65 years: 4 (1, 9) days
Median number of days of hospitalization among those not admitted to ICU (interquartile range) [††]	18-49 years: 3 (2, 5) days 50-64 years: 4 (2, 7) days ≥65 years: 6 (3, 10) days
Median number of days of hospitalization among those admitted to ICU (interquartile range)[††,§§]	18-49 years: 11 (6, 20) days 50-64 years: 14 (8, 25) days ≥65 years: 12 (6, 20) days
Percent admitted to ICU among those hospitalized[††]	18-49 years: 23.8% 50-64 years: 36.1% ≥65 years: 35.3%
Percent on mechanical ventilation among those hospitalized. Includes both non-ICU and ICU admissions[††]	18-49 years: 12.0% 50-64 years: 22.1% ≥65 years: 21.1%
Percent that die among those hospitalized. Includes both non-ICU and ICU admissions[††]	18-49 years: 2.4% 50-64 years: 10.0% ≥65 years: 26.6%
Median number of days of mechanical ventilation	Overall: 6 (2, 12) days

(interquartile range)**	
Median number of days from symptom onset to death (interquartile range)**	18-49 years: 15 (9, 25) days 50-64 years: 17 (10, 26) days ≥65 years: 13 (8, 21) days
Median number of days from death to reporting (interquartile range)¶¶	18-49 years: 19 (5, 45) days 50-64 years: 21 (6, 46) days ≥65 years: 19 (5, 44) days

* McAloon, C.G., Collins, A., Hunt, K., Barber, A., Byrne, A., Butler, F., Casey, M., Griffin, J.M., Lane, E., McEvoy, D. and Wall, P. (2020). The incubation period of COVID-19: A rapid systematic review and meta-analysis of observational research. *medRxiv*.

† He, X., Lau, E.H., Wu, P., Deng, X., Wang, J., Hao, X., Lau, Y.C., Wong, J.Y., Guan, Y., Tan, X. and Mo, X. (2020). Temporal dynamics in viral shedding and transmissibility of COVID-19. *Nature medicine*, *26*(5), pp.672-675.

§ The point estimate is the geometric mean of the location specific point estimates of the ratio of estimated infections to reported cases, from Havers, F.P., Reed, C., Lim, T., Montgomery, J.M., Klena, J.D., Hall, A.J., Fry, A.M., Cannon, D.L., Chiang, C.F., Gibbons, A. and Krapiunaya, I., 2020. Seroprevalence of antibodies to SARS-CoV-2 in 10 sites in the United States, March 23-May 12, 2020. *JAMA Internal Medicine*. The lower and upper bounds for this parameter estimate are the lowest and highest point estimates of the ratio of estimated infections to reported cases, respectively, from Havers et al., 2020.

¶ Estimates only include symptom onset dates between March 1, 2020 – July 15, 2020. Estimates represent time to obtain SARS-CoV-2 tests among cases who tested positive for SARS-CoV-2.

Estimates based on and data from Data Collation and Integration for Public Health Event Response (*DCIPHER*).

** Estimates only include symptom onset dates between March 1, 2020 – July 15, 2020 to ensure cases have had sufficient time to observe the outcome (hospital discharge or death). Data for 17 year olds and under are suppressed due to small sample sizes.

†† Based on data reported to COVID-NET by Aug 1, 2020. Data for 17 year olds and under are suppressed due to small sample sizes. https://gis.cdc.gov/grasp/COVIDNet/COVID19_5.html.

§§ Cumulative length of stay for persons admitted to the ICU, inclusive of both ICU and non-ICU days.

¶¶ Estimates only include death dates between March 1, 2020 – July 15, 2020 to ensure sufficient time for reporting. Data for 17 year olds and under are suppressed due to small sample sizes.