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Public Health Measures and the Reproduction Number of SARS-CoV-2

Thomas V. Inglesby, MD

Coronavirus disease 2019 (COVID-19) is a respiratory infectious disease caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), first detected in early December 2019 in Wuhan, China. It has since spread throughout the world.

One measure of viral spread is the R_O, the expected number of secondary infectious cases produced by a primary infectious case. This calculation is used to determine the potential for epidemic spread in a susceptible population. The effective reproduction number, R_t, determines the potential for epidemic spread at a specific time t under the control measures in place (**Figure 1**). To evaluate the effectiveness of public health interventions, the R_t should be quantified in different settings, ideally at regular and frequent intervals (eg, weekly).

In an article published in *JAMA*, Pan and colleagues[1] evaluated the association of public health interventions with the epidemiological features of the COVID-19 outbreak in Wuhan by 5 periods, according to key events and interventions, including *cordons sanitaire*, traffic restriction, social distancing, home confinement, centralized quarantine, and universal symptom survey.

In their study, Pan et al[1] determined the R_t as an indicator to measure the transmission of SARS-CoV-2 before and after the interventions. In a figure in their article, the authors show the extraordinary change in the rate of transmission of SARS-CoV-2 associated with reducing social interaction (**Figure 2**). In early through mid-January 2020, the SARS-CoV-2 epidemic in Wuhan had an R_t of 3 to 4. In other words, each case spread to an average of 3 to 4 others. That is a striking number: compare it to the R_t of 1.4 to 1.7 for influenza, which is a disease that spreads widely around the world every year. Couple that with the fact that each new generation of SARS-CoV-2 cases occurs every 5 days, and it is clear to see how this epidemic was spreading out of control.

On January 23, a series of major actions were taken by the Chinese government, including a city lockdown and home and centralized quarantines. Some of the measures put in place in Wuhan

Figure 1. Concepts of the Effective Reproduction Number

The effective reproduction number (R_t) of a viral infection is the mean number of additional infections caused by an initial infection in a population at a specific time.

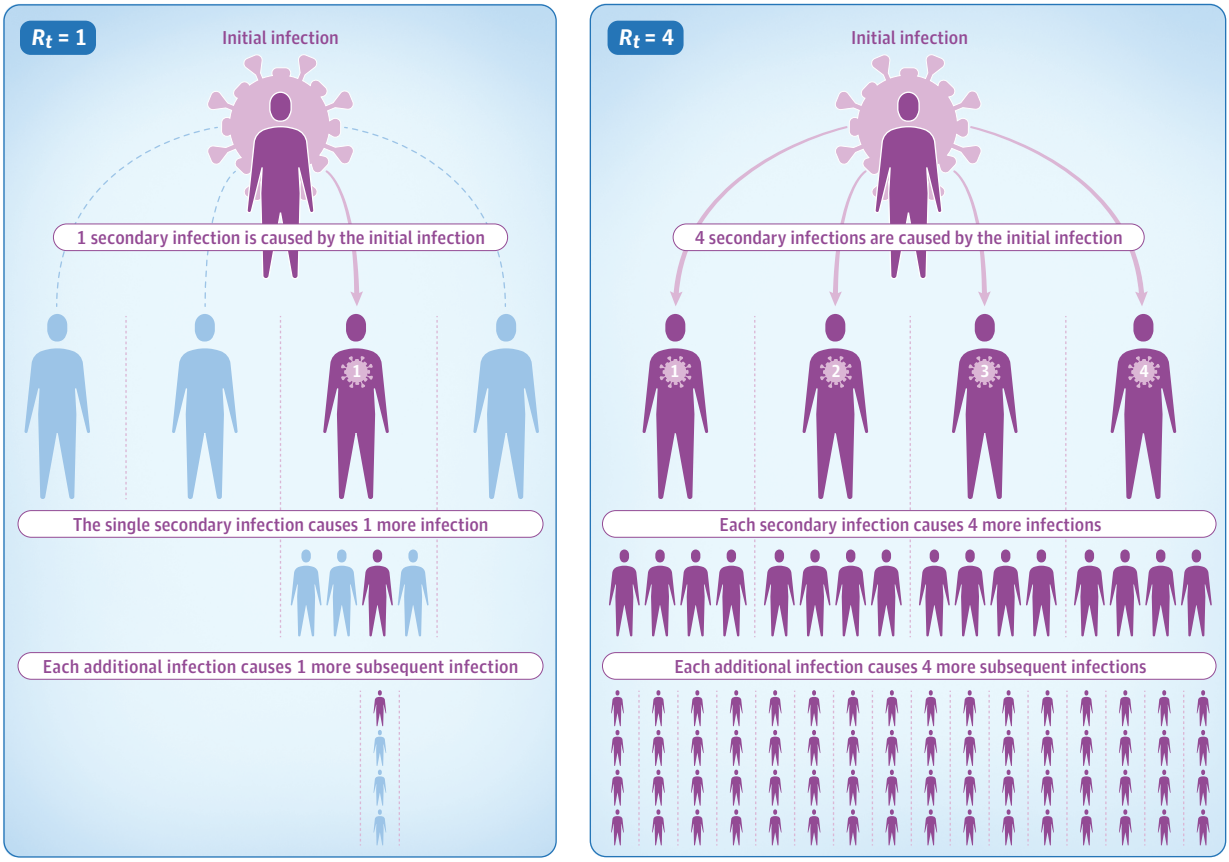
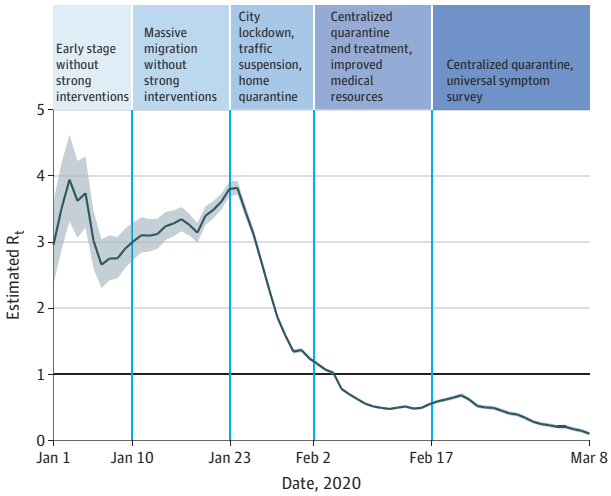


Figure 2. The Effective Reproduction Number (R_t) Estimates Based on Laboratory-Confirmed Coronavirus Disease 2019 (COVID-19) Cases in Wuhan, China



The effective reproduction number R_t is defined as the mean number of secondary cases generated by a typical primary case at time t in a population, calculated for the whole period over a 5-day moving average. Results are shown since January 1, 2020, given the limited number of diagnosed cases and limited diagnosis capacity in December 2019. The darkened horizontal line indicates R_t = 1, below which sustained transmission is unlikely so long as antitransmission measures are sustained, indicating that the outbreak is under control. The 95% credible intervals (CrIs) are presented as gray shading. From Pan et al.[1]

would not be deemed either societally acceptable or practically feasible in many parts of the world; eg, complete control of movement for months or compulsory isolation in facilities. Other measures put in place at that time (not shown in this figure but widely reported elsewhere) included business closures, school closures, and cancellation of gatherings, which also contributed to substantially lowering social interaction. Those measures have become the core of social distancing interventions taken around the world to control the spread of SARS-CoV-2.

When all those measures were taken collectively in Wuhan, the R_t of the epidemic declined to below 1 within weeks. When an R_t decreases below 1 for a given disease in a given place, disease spread slows and the epidemic has the potential to be controlled in that area.

Figure 2 illustrates what the goal must be now around the world. Until a safe and effective vaccine is developed and globally disseminated, countries need to use some combination of social distancing measures to work to bring their R_t below 1. Hopefully, countries will find strategies to implement social distancing in ways that allow economies to come back and society to resume some normalcy. Given the severe economic and societal consequences of these strategies, continued efforts should be made to study the need for and effectiveness of social distancing measures as they are put in place and relaxed in the time ahead. Beyond the larger measures of business and school closures and cancellation of gatherings, individual actions to keep physical distances of at least 6 feet, wear cloth masks in public, and telecommute to work will help reduce the R_t. Absent any social distancing at all, SARS-CoV-2 would likely revert to its pattern of spread as it was back in early January, with an R_t in the 2 to 4 range and doubling in size every 5 days, until a substantial portion of the population develops immunity through infection and recovery, or through vaccination.

The US Centers for Disease Control and Prevention (CDC) should regularly report on the R_t for the US and for each of the 50 states so that political and public health leaders can gauge how well the combined organizational and individual social distancing measures in place around the country are working to diminish transmission of this virus. The CDC should then communicate this transparently to the public to increase public buy-in and understanding of the actions being taken to slow the spread of COVID-19.

ARTICLE INFORMATION

Author Affiliation: Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland.

Corresponding Author: Thomas V. Inglesby, MD, Johns Hopkins Bloomberg School of Public Health, 621 E Pratt St, Baltimore, MD 21202 (tinglesby@jhu.edu).

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