Re: Mathematical modeling of SARS: Cautious in all our movements

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Send letter to journal:
Re: Re: Mathematical modeling of SARS: Cautious in all our movements

Email Ying-Hen Hsieh, et al.

Dear Editor

Dr Nishiura [1] accentuated that caution must be exercised in using mathematical models to ascertain the recent SARS epidemics.

The key issue, as we believe, is to understand the model and its results for what they are and, more importantly, for what they are not. It is especially true with the basic reproductive number R0, or its variant the effective reproductive number at time t Rt, which has been estimated for the recent SARS outbreaks in Beijing, Hong Kong,, Toronto, Taiwan, and Singapore in several recent articles (e.g. [2-6]). R0, the average number of secondary infections caused by an infective person upon entering a totally susceptible population, is a useful tool to gauge the initial trend of an epidemic. It is also often misunderstood and misused. Indeed, a recent news feature in Nature [7] described the basic reproductive number R0 as "A measure of a disease's infectiousness" corresponds to how many people, on average, are infected by each patient in the absence of any control measures, which erroneously left out the important requirement that the patient must be an index case in that population, i.e. all possible contacts of that person are susceptible to infection.

The effective reproductive number at time t Rt =R0 x(t), where x is the susceptible proportion of population at time t, measures number of infections caused by a new case at time t.[3] It is more important as a mean to understand the progression of the epidemic, taking into consideration the control measures, behavior changes, and climate as they have all been proven to be important in the case of SARS. Moreover, one can approximate the average growth rate of an epidemic over a given time interval while the epidemic is underway from the cumulative case data. From which one could then estimate the "mean effective reproductive number of the observed time period" R*, i.e. the average number of secondary infections caused by one infective person during the observed time interval. The precise definition gives the public officials a clear chronology of progression (or cessation) of the epidemic, albeit retrospectively.

For illustration, we used the cumulative number of probable SARS cases in Taiwan by onset date from March 12 to June 15,[8] exponential curve fitting with first-order autocorrelation in the error structure,[9] and the period of SARS infectivity of 29.03

days (i.e. time from onset to death or discharge) estimated from [10] to obtain the mean effective reproductive numbers for the five distinct periods during March 12 - June 15 (Table 1). A chronology of relevant events of importance is given as a footnote of Table 1. Figure 1 paints a clear picture of slowly growing epidemic in the beginning, to the outbreak kindled by the admission of first SARS patient to Ho Ping Hospital, the site of first hospital cluster infections, on April 9. The peak period of infections (4/11-4/26) ended with the shutdown of Ho Ping Hospital on April 24. The series of hospital clusters in Taipei and subsequently in the southern port city of Kaohsiung finally subsided with the May 11 shutdown of Chang Gung Hospital in Kaohsiung, due to successful intervention efforts to stop nosocomial infections, the last of which occurred shortly before June 9 the onset date of the last hospital infection in Taiwan. The result clearly points to the important lesson from the outbreak in Taiwan shutdown of hospitals where cluster infections have occurred had been a crucial step in breaking the local chains of transmissions. The effect of quarantine measures, however, is less clear and requires further study, perhaps with mathematical modeling. Clearly, retrospective mathematical modeling is an important reference for public health policy makers intending to contain possible future outbreaks with the most effective intervention measures as long as we understand them for what they are and what they are not.

Table 1 Mean effective reproductive numbers R* for each of the five time periods with events of relevance during the time periods

?	Mean	SD	95%Lower CI	95% Upper CI
3/12 - 4/10	2.24692	0.27770	1.72717	2.40090
4/11 - 4/26	3.48070	0.42094	2.62280	4.15280
4/27 - 5/12	1.42828	0.05934	1.57454	1.78713
5/13 - 5/27	0.27770	0.02900	0.58469	0.76811
5/28 - 6/15	0.08410	0.00958	0.07083	0.10498

3/18 ? Implementation of Level A quarantine.

4/09 ?Admission of first SARS patient to Ho Ping Hospital.

4/24 ?Shutdown of Ho Ping Hospital.

4/28 ?Implementation of Level B quarantine.

5/11 ?Shutdown of Chang Gung Hospital.

6/15 ?Onset date of the last hospital infection.

References

(1) Nishiura H. Mathematical modeling of SARS: cautious in all our movements. J Epidem Com Health 2003; In Press.

(2) Riley S, Fraser C, Donnelly C, Ghani AC, Abu-Raddad LJ, Hedley AJ, et al. Transmission dynamics of the etiological agents of SARS in Hong Kong: Impact of public health interventions. Science 2003; 300: 961-66 (20 June 2003) Published online 23 May 2003 (10.1126/science.1086478)

(3) Lipsitch, M, Cohen T, Cooper B, Robins JM, Ma S, James L, et al. Transmission dynamics and control of severe acute respiratory syndrome. Science 2003; 300: 1966-70 (20 June 2003) Published online 23 May 2003; 10.1126/science.1086616

(4) Zhou G, & Yan G. Severe Acute Respiratory Syndrome epidemics in Asia. Emerg Infect Dis 2003; 9(12), In Press.

(5) Hsieh YH, Chen CWS, & Hsu SB. The Severe Acute Respiratory Syndrome outbreak in Taiwan: Lessons to be learned. Emerg Infect Dis 2003; To Appear.

(6) Chowell G, Fenimore PW, Castillo-Garsow MA, & Castillo-Chavez C. SARS outbreaks in Ontario, Hong Kong, and Singapore: the role of diagnosis and isolation as a control mechanism. J Theoret Biol 2003; 224: 1-8.

(7) Pearson H, Clarke T, Abbott A, Knight J, & Cyranoski D. SARS: what have we learned? Nature 2003; 424(6945):121-6. Nature 424, 121: 126(2003) (10 July 2003).

(8) Center for Disease Control (Taiwan). Available at http://www.cdc.gov.tw/sarsen

(9) Hsieh YH,. & Chen CWS. Severe Acute Respiratory Syndrome: Numbers don't tell the whole story. British Medical J 2003; 326: 1395-1396.

(10) Donnelly C, Ghani AC, Leung GM, Hedley AJ, Fraser c, Riley S, et al. Epidemiological determinants of spread of causal agent of severe acute respiratory syndrome in Hong Kong. Lancet 2003; 361(9371): 1761-66. (May 24 2003) Available at http://image.thelancet.com/extras/-3art4453web.pdf.