Research Letter

Spread of Covid-19 in Bangladesh: Evidence from Reproduction Number

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Abstract

The study estimates time-dependent reproduction number of coronavirus in case of Bangladesh using incidence data from March 9, 2020 to June 25, 2020. The mean reproduction number is 1.40 (95% Cl 1.11, 1.73), which indicates expected continuation of outbreak in Bangladesh. People should maintain physical distance with own accord.

Text

This study attempts to estimate initial and time-dependent (R_t) reproduction number of coronavirus disease (COVID-19) in case of Bangladesh. Reproduction number is a well-known indicator of disease transmissibility. It indicates number of secondary cases infected through per infected primary case. Reproduction number is interpreted in different way in literature, for example as a ratio or rate (*1*) but it is a dimensionless number. It is divided mainly into two categories. One category distinguishes between whether reproduction number is estimated in the beginning of disease outbreak (initial reproduction number) or it is time-dependent (R_t) (*2*). Other category distinguishes between whether reproduction number estimates expected number of secondary cases produced by a typical primary case in an entirely susceptible population (basic reproduction number, R_0) (*1*) or "actual average number of secondary cases per primary case" in population with immunity (effective reproduction number, R) (*1,3*). Basic reproduction number shows disease transmissibility potential, whereas effective reproduction number shows actual transmissibility of disease.

This study compares three methods to find the best fitting method to estimate reproduction number for Bangladesh. The methods are exponential growth (EG) (*4*), maximum likelihood (ML) estimation (*5*) and time-dependent (TD) reproduction number (*3*). Estimations are implemented using Ro package (*2*) of R software. EG and TD estimates effective reproduction number (R) whereas ML estimates basic reproduction number (R_0). These models do not assume any mixing in population[1]. ML estimation requires incidence data from very first case (*3*). Both EG and ML methods require specifying period when incidence data first shows exponential growth. The present study uses default of Ro package to specify that period, which is the maximum incidence from the first case of epidemic (*2*). EG and ML method indicates initial reproduction number. Contrary to first two approaches, TD method provides reproduction number over time. Mean R_t is reported in this research letter. Although all of these methods provide average reproduction number, marginal reproduction number can be estimated from time-dependent approach.

[1] Although ML assumes homogenous mixing in population, authors indicate that this assumption can be relaxed (*5*).

Data used for this study includes daily COVID-19 new cases from March 3, 2020 to June 25, 2020 (https://data.europe.eu/euodp/en/data/dataset/covid-19-coronavirus-data). Serial interval (SI) is a crucial input for reproduction number estimation (*4*). SI is the time between symptoms' onset in infector and recipient. To use serial interval in reproduction number estimation, first we collect pair data on time range of infector and infected when they become symptomatic after being infected. Then using parametric distribution, we get posterior sample of serial interval distribution. In the later step, including those distributions with disease incidence data and time, we estimate reproduction number (*6*)

In case of Bangladesh, data is not available to estimate mean and standard deviation of serial interval. Therefore, this study compares mean of serial interval (3.96 to 7.5 days) found in literature of COVID-19 (*7, 8, 9, 10*). Bangladesh acknowledges symptomatic and asymptomatic transmission route of COVID-19 (https://m.somoynews.tv/pages/details/212979). To choose suitable serial interval, this study estimates reproduction number with different distribution including symptomatic, pre-symptomatic and asymptomatic transmission routes with EG, ML, and TD approaches (Table 1). For each serial interval, this study gets one method that fits best. Later, one best fitted method is chosen comparing all best fitted methods by plotting observed and fitted epidemic curve. Observed and predicted incidences of best chosen serial interval are shown in figure below.

Table 1. Reproduction number of COVID-19 for Bangladesh estimated using different serial intervals

Serial Interval distribution (mean and standard deviation)	Reproduction number			
	Exponential growth	Maximum Likelihood	Time-dependent	Best fit
(7) Lognormal(3.96, 4 .75)	1.22 [1.218 , 1.221]	1.16 [1.15 , 1.17]	1.30 [1.04, 1.61]	TD
(8) Lognormal(4.7, 2.9)	1.27 [1.26,1.27]	1.20 [1.19,1.21]	1.49 [1.17,1.84]	TD
(8) Weibull(4.6, 4.8)	1.28 [1.276-1.280]	1.21 [1.20,1.22]	1.40 [1.11,1.73]	TD
(9) Gamma(6.5, 4.7)	1.37 [1.36,1.37]	1.28 [1.27,1.29]	1.61 [1.27,2.00]	TD
(10) Gamma(7.5, 3.4)	1.44 [1.436,1.443]	1.34 [1.32,1.35]	2.00 [1.58,2.46]	TD

Exponential growth (EG), maximum likelihood (ML), and time-dependent (TD) methods are used to estimate reproduction number. EG and ML estimate basic reproduction number and TD estimates effective reproduction number. TD is found to be best methods for all serial intervals. TD method with weibull (4.6, 4.8) is best fitted among all serial interval and methods (shaded in olive green). Numbers in parentheses shows 95% Cl.

Among all serial interval preferences, TD method predicts incidences best. Weibull distribution of serial interval with mean 3.96 and standard deviation 4.8 fits best among all serial interval distribution presented in the table, which is shaded in olive green. The second best method that predicts incidence of COVID-19 in Bangladesh is TD method with lognormal distribution of serial interval with mean 3.96 and standard deviation 4.75. The mean reproduction number for Bangladesh is 1.40 [95% Cl 1.11, 1.73]. Other estimates of reproduction number in case of Bangladesh are 1.82[2], 3[3], 1.01[4], 0.96[5]. All of these studies use effective reproduction number.

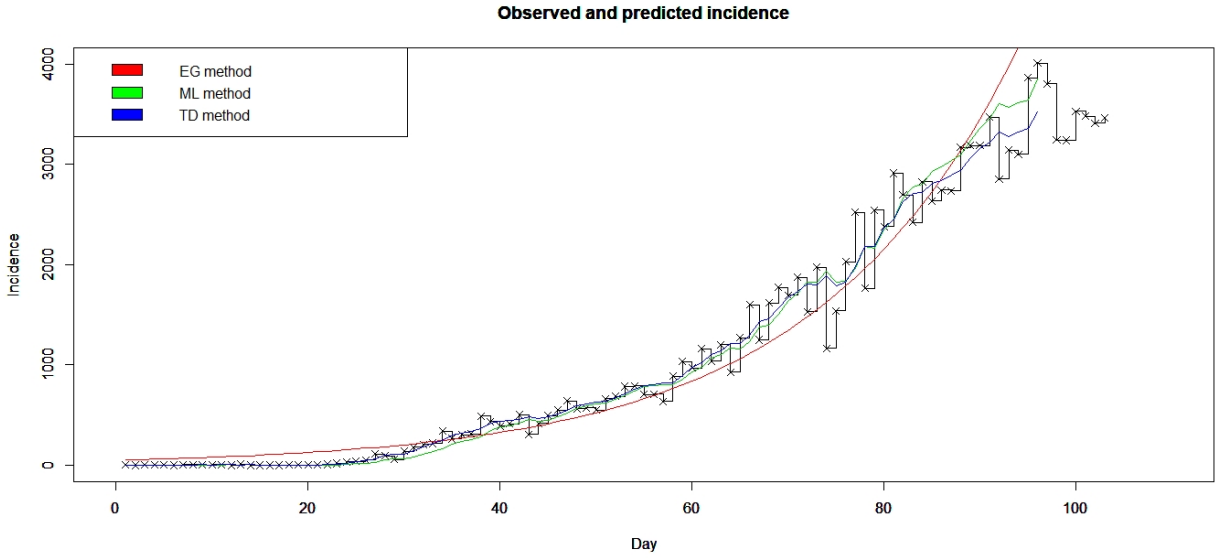

Figure. Observed incidence number and predicted incidence of COVID-19 in case of Bangladesh estimated using exponential growth (EG), maximum likelihood (ML), and time-dependent (TD) methods. Black stair with cross shows observed incidences. Red, green, and blue lines shows predicted incidences estimated using EG, ML, and TD methods respectively.

This study estimates reproduction number of COVID-19 in case of Bangladesh, which may help people to understand the spread of COVID-19 in Bangladesh and take necessary steps. As reproduction number in case of Bangladesh is >1, that the outbreak is expected to continue. Such reproduction number and upward trend of incidences indicate that lockdown does not have much

[2] Using time-dependent approach for first 65 days (March 8 – May 11, 2020) with serial interval reported in case of Wuhan, China. https://assets.researchsquare.com/files/rs-32412/v1_stamped.pdf . Accessed on July 3, 2020

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[4] Using SIR Model.. https://sites.google.com/site/shafiunihe/recent-work-on-covid-19 . Accessed on July 3, 2020

[5] Based on incidence of death. https://mrc-ide.github.io/covid19-short-term-forecasts/index.html . Accessed on July 3, 2020

effect to slow down infection. In case of asymptomatic transmission route, people should maintain physical distance with own accord.

The study does not consider delay in reporting of incidences. Moreover, this study does not estimate serial interval in case of Bangladesh. Mean and standard deviation of serial interval, estimated in case of several other countries, were used for the exercise. Demography of some such countries are different from Bangladesh. Self-selection bias is not considered for the estimation. Therefore, the study does not forecast reproduction number. Further study may estimate serial interval in case of Bangladesh and then forecast reproduction number with proper adjustment of data for better understanding.

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