The reproductive numbers of SARS-CoV-2 vary depending on the compartmental model used during epidemiological modeling

The reproductive numbers in compartmental modeling

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Teasure :

We illustrate the correct way to compare reproductive numbers obtained from various compartmental models used in mathematical epedimiology.

Dear Editors,

It is in reference to a recently published research letter in your prestigious journal,[1] the authors have carried out a systematic review using the meta-analysis and presented the estimates of the Basic Reproduction Number (R_0) and the Effective Reproduction Number (R_e) for different countries across the globe. They presented different estimation methods using different compartmental models for different time periods during the Delta and Omicron waves of the SARS-CoV-2 infections in the published studies extracted from abstract and publication databases available online. Out of shortlisted 1914 downloaded articles related to the Delta and Omicron infection spread data, they have further screened down to the 15 published studies describing R_0 and R_e for the Delta and Omicron wave of SARS-CoV-2. The estimates of R_0 and R_e are presented in the table, together with the relative *R* numbers for the Omicron wave with respect to the Delta wave infection spread data. [1] At page no. 2 in the table, it may be observed that the relative number of estimate of R_0 for the Omicron over Delta was 3.76 for the analysis carried out by Yu *et al.* (2021) on the data of infection dissemination during the time period from 12 June 2020 to 1 November 2021. [2] Yu *et al.* (2021) have applied already established compartmental model Susceptible-Exposed-Infectious-Hospitalized-Recovered-Death (SEIHRD). [2] In the study conducted by Nicolo *et al.* (2022), the relative R numbers ranged from 0.25 to 3.0. [3] They have used data of infection spread between 1 May 2021 to 23 November 2021, which is an overlapping time period with the data used by Yu *et al.* (2021) in the earlier study. [2] However, Nicolo *et al.* (2022) have applied a different compartmental model i.e. the Susceptible-Infectious-Latent-Recovered (SILR). [3] Both the studies used data obtained from the same country, South Africa, with an overlapping time period but because the two studies

employed distinct compartmental models, it yielded a huge difference in the relative *R* numbers obtained for Omicron over Delta wave infection data. A similar observation could be seen for R_e at page no. 3 in the table. [1] From the table, it is also interesting to note that the estimated value of R_e for the Omicron over Delta wave infection spread data during the same time period up to 13 December 2021 in the study carried out by Ontario Agency for Health Protection and Promotion for United Kingdom (UK) is 3.7. [4] In this study, Logistic Growth Model was employed. [4] However, in another study, [5] in the neighboring country, The Netherlands, the relative estimate of R_e for Omicron over Delta wave data for the time period up to December 2021 employing the stochastic Susceptible-Infectious-Recovered (SIR) compartmental model was calculated as 0.88. [5] This relative R_e is quite low in comparison to the study carried out in the UK for the same time period. [4] These variations in the estimates of R_0 and R_e are because of the use of different compartmental models. [6] For instance, the formulae for R_0 for SIR and SEIR compartmental models are $R_0 = 1 + rD_I$ and $R_0 = (1 + rD_I)(1 + rD_E)$ respectively, [6] where, r is the growth rate, D_I is the average duration of infectiousness, and D_E is the average duration of latency. The relation between R_0 and R_e is represented by $R_e = R_0.X$, where X is the fraction of the susceptible hosts in a population. Therefore, if R_0 is affected by the use of a different compartmental model, the R_e will also be changed. The estimates of R_0 and R_e are changed not only due to the use of different compartmental models but also due to the change of different biological situations. [6] Thus, it is recommended to compare the R_0 and R_e from two different datasets for estimating the relative *R* numbers, when a specific compartmental model as well as similar mitigation measures must be applied for the two scenarios. The different compartmental models have different formulae to calculate the *R* numbers; therefore these obtained *R* numbers from different models cannot be compared. Conclusively, the analysis presented, [1] may not represent the true situation during the pandemic.

Authors' contributions

SY and YA prepared the response to the research letter. Both the authors worked together on the draft of the manuscript and approved the final version.

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Conflict of interest

We do not have any conflict of interest pertaining to the work presented.

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