Estimating the Epidemic Size of Super-spreading Coronavirus Cluster Outbreaks in Real-time

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Background: Novel coronaviruses have emerged and caused major epidemics and pandemics in the past two decades, including severe acute respiratory syndrome coronavirus 1 (SARS-CoV-1), Middle East respiratory syndrome coronavirus (MERS-CoV), and severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) which leads to current COVID-19 pandemic. Coronaviruses are marked by their potential transmission threat of disproportionally large clusters from super-spreading events (SSEs). Real-time assessment of the size of SSEs is required for rapid surveillance and mitigation responses.

Methods: We developed a statistical framework based on “back calculation” to estimate the epidemic size of ongoing cluster outbreaks. We first validated the framework in simulated scenarios with the characteristics of SARS, MERS, and COVID-19 SSEs. We then retrospectively applied the method to the Amoy Gardens SARS outbreak in Hong Kong in 2003, three nosocomial MERS outbreaks in South Korea in 2015, and two COVID-19 outbreaks in restaurants in Hong Kong in 2020 as case studies.

Results: The accuracy and precision of our estimates improve with longer observation time, larger cluster size, less uncertainty in onset-to-confirmation delay, and more accurate prior information on the incubation period distribution. The 95% credible interval (CrI) of the estimates contained the true cluster size after 37% of cases were reported in the Amoy Garden SARS outbreak in Hong Kong, 41-62% of cases were observed in the three nosocomial MERS outbreaks in South Korea and 76-86% of cases were confirmed in the two COVID-19 cluster outbreaks in Hong Kong.

Conclusion: Our framework can be readily integrated into coronavirus surveillance systems to estimate the cluster sizes of SSEs in real-time. With intensive contact tracing to bring SSEs under control, it is possible to predict the epidemic size of SSEs before 50% of the cases are observed.

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