Modelling study estimates impact of physical distancing on reducing spread of COVID-19

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A new modelling study conducted in a simulated Singapore setting has estimated that a combined approach of physical distancing interventions, comprising quarantine (for infected individuals and their families), school closure, and workplace distancing, is most effective at reducing the number of SARS-CoV-2 cases compared with other intervention scenarios included in the study.

While less effective than the combined approach, quarantine plus workplace measures presented the next best option for reducing SARS-CoV-2 cases, followed by quarantine plus school closure, and then quarantine only. All intervention scenarios were more effective at reducing cases than no intervention.

The study, published in *The Lancet Infectious Diseases* journal, is the first of its kind to investigate using these options for early intervention in Singapore using simulation. Despite heightened surveillance and isolation of individuals suspected to have COVID-19 and confirmed cases, the risk is ongoing, with the number of cases continuing to increase in Singapore. Schools have not been closed, and workplace distancing is recommended, but it is not national policy [correct as of 23.03.2020].

The study found that the combined approach could prevent a national outbreak at relatively low levels of infectivity (basic reproductivity value (R0) = 1.5), but at higher infectivity scenarios (R0 = 2.0 (considered moderate and likely) and R0 = 2.5 (considered high)), outbreak prevention becomes considerably more challenging because although effective at reducing infections, transmission events still occur.

Dr. Alex R Cook, National University of Singapore, said: "Should local containment measures, such as preventing disease spread through contact tracing efforts and, more recently, not permitting short-term visitors, be unsuccessful, the results of this study provide policy makers in Singapore and other countries with evidence to begin the implementation of enhanced outbreak control measures that could mitigate or reduce local transmission rates if deployed effectively and in a timely manner."

To assess the potential impact of interventions on outbreak size, should local containment fail, authors developed an individual-based influenza epidemic simulation model, which accounted for demography, individual movement, and social contact rates in workplaces, schools, and homes, to estimate the likelihood of human-to-human transmission of SARS-CoV-2. Model parameters included how infectious an individual is over time, the proportion of the population assumed to be asymptomatic (7.5%), the cumulative distribution function for the mean incubation period (with the virus that causes SARS and the virus that causes COVID-19having the same mean incubation period of 5.3 days), and the duration of hospital stay after symptom onset (3.5 days).

Using this model, authors estimated the cumulative number of SARS-CoV-2 infections at 80 days, after detection of 100 cases of community transmission. Three values for the basic reproduction number (R0) were chosen for the infectiousness parameter, including relatively low (R0=1.5), moderate and likely (R0=2.0), and high transmissibility (R0=2.5). The basic reproduction numbers were selected based on analyses of data from people with COVID-19 in Wuhan, China.

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In addition to a baseline scenario, which included no interventions, four intervention scenarios were proposed for implementation after failure of local containment: 1) isolation of infected individuals and quarantine of their family members (quarantine); 2) quarantine plus immediate school closure for 2 weeks; 3) quarantine plus immediate workplace distancing, in which 50% of the workforce is encouraged to work from home for 2 weeks; 4) a combination of quarantine, immediate school closure, and workplace distancing. These interventions follow some policy options currently being undertaken (quarantine and some workforce distancing) by the Singaporean Ministry of Health, as standard interventions for respiratory virus control.

For the baseline scenario, when R0 was 1.5, the median cumulative number of infections at day 80 was 279,000, corresponding to 7.4% of the resident population of Singapore. The median number of infections increased with higher infectivity: 727,000 cases when R0 was 2.0, corresponding to 19.3% of the Singaporean population, and 1,207,000 cases when R0 was 2.5, corresponding to 32% of the Singaporean population.

Compared with the baseline scenario, the combined intervention was the most effective, reducing the estimated median number of infections by 99.3% when R0 was 1.5 (resulting in an estimated 1,800 cases). However, at higher infectivity scenarios, outbreak prevention becomes considerably more challenging. For the combined approach scenario, a median of 50,000 cases were estimated at R0 of 2.0 (a reduction of 93.0% compared to baseline) and 258,000 cases at R0 of 2.5 (a reduction of 78.2% compared to baseline).

Authors also explored the potential impact if the proportion of asymptomatic cases in the population was greater than 7.5% (the proportion of people who are able to transmit despite having no or mild symptoms). Even at a low infectivity (when the R0 was 1.5 or lower), a high asymptomatic proportion presents challenges. Assuming increasing asymptomatic proportions up to 50·0%, up to 277,000 infections were estimated to occur at day 80 with the combined intervention, relative to 1,800 for the baseline at R0 = 1.5.

Dr. Alex R Cook added: "If the preventive effect of these interventions reduces considerably due to higher asymptomatic proportions, more pressure will be placed on the quarantining and treatment of infected individuals, which could become unfeasible when the number of infected individuals exceeds the capacity of health-care facilities. At higher asymptomatic rates, public education and case management become increasingly important, with a need to develop vaccines and existing drug therapies."

The authors note several limitations in their study, including dated census population data, impact of migrant movement, the impact of seeding of imported cases (transmissions originating from outside of Singapore) the dynamics of contact patterns between individuals, and other unforeseen factors. Of note, epidemiological characteristics of COVID-19 remain uncertain in terms of the transmission and infectivity profile of the virus; therefore, estimates of the time between symptom onset and admission to hospital, how infectious an individual is over time, and the asymptomatic rate were based on SARS-CoV.

Writing in a linked Comment, Joseph A Lewnard, University of California, Berkeley, USA, and Nathan C Lo, University of California, San Francisco, USA, say: "Although the scientific basis for these interventions might be robust, ethical considerations are multifaceted. Importantly, political leaders must enact quarantine and social-distancing policies that do not bias against any population group. The legacies of social and economic injustices perpetrated in the name of public health have lasting repercussions. Interventions might pose risks of reduced income and even job loss, disproportionately affecting the most disadvantaged populations: policies to lessen such risks are urgently needed. Special attention should be given to protections for vulnerable populations, such as homeless, incarcerated, older, or disabled individuals, and undocumented migrants. Similarly, exceptions might be necessary for certain groups, including people who are reliant on ongoing medical treatment."

More information: Joel R Koo et al, Interventions to mitigate early spread of SARS-CoV-2 in Singapore: a modelling study, *The Lancet Infectious Diseases* (2020). DOI: 10.1016/S1473-3099(20)30162-6

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