The Role of Vaccination in the Control of SARS

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Summary
Severe acute respiratory syndrome (SARS) is a viral respiratory illness caused by SARS coronavirus (SARS-CoV). The first cases were reported in the Southern China Province of Guangdong [?]. The 2003 epidemic was driven by international travel and lack of knowledge of its etiological agent. The World Health Organization reported 8,422 cases with 916 deaths as of August of 2003. Containment of the SARS epidemic was possible by rapid diagnosis and effective isolation of infectious cases.

SARS symptoms include high fever, headaches, body aches, mild respiratory symptoms at the outset, diarrhea, and usually a development of a dry cough within seven days of infection [?]. Most SARS patients develop pneumonia [?]. SARS is transmitted by close person-to-person contact [?]. The mean incubation period for SARS (the period that a person is infected but not infectious) is approximately 6.4 days [?]. Suspected cases are hospitalized at a rate 1/4.85 days−1 and recovered individuals leave hospitals on average 23.5 days after diagnosis, or die on average 35.9 days after diagnosis [?].

We assess pre-outbreak and during-outbreak vaccination as control strategies for SARS epidemics. Our model includes susceptible, latent (traced and untraced), infectious, quarantined/isolated and recovered classes. We take parameter estimates from published literature.

We explored different scenarios for control including the effects of levels of pre-outbreak successfully vaccinated individuals as the number of secondary cases by a primary infectious case (R0) and the final epidemic size.

The basic reproductive number is given by

\[ R_0(\sigma) = \beta(1-\sigma)(1-\rho)(\theta/\delta+\gamma_2) + (1-\rho)(1-\theta)(\rho/\alpha)(\delta+\gamma_1) + (1-\rho)(1-\theta)(\rho/\alpha+\delta+\gamma_1) + (\rho/\delta+\gamma_2). \]

Assuming 40% of quarantine and isolation individuals contribute to new infections throughout an outbreak, a large number of cumulative cases occur even when vaccination is implemented. In this case, a significant reduction in total cumulative cases is observed after at least 27% of the initial population is vaccinated. Higher vaccination rates do not affect the percentage of cumulative cases as significantly, but have an impact in the reduction of the to-

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Parameter definition and baseline values for the model parameters.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Definition</th>
<th>Baseline Value</th>
<th>Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \beta )</td>
<td>Transmission rate per day</td>
<td>0.25</td>
<td>[?]</td>
</tr>
<tr>
<td>( 1/k )</td>
<td>Mean incubation period (days)</td>
<td>6.37</td>
<td>[?]</td>
</tr>
<tr>
<td>( 1/\gamma_1 )</td>
<td>Mean infectious period (days)</td>
<td>28.4</td>
<td>[?]</td>
</tr>
<tr>
<td>( 1/\gamma_2 )</td>
<td>Mean infectious period for diagnosed individuals</td>
<td>23.5</td>
<td>[?]</td>
</tr>
<tr>
<td>( 1/\alpha )</td>
<td>Mean period before diagnosis (days)</td>
<td>4.85</td>
<td>[?]</td>
</tr>
<tr>
<td>( \delta )</td>
<td>Disease induced death rate per day</td>
<td>0.0279</td>
<td>[?]</td>
</tr>
<tr>
<td>( \sigma )</td>
<td>Proportion of susceptibles successfully vaccinated</td>
<td>[0, 1]</td>
<td>[?]</td>
</tr>
<tr>
<td>( \rho )</td>
<td>Proportion of latent population traced</td>
<td>[0, 1]</td>
<td>[?]</td>
</tr>
<tr>
<td>( \theta )</td>
<td>Proportion of untraced latent that self-quarantine</td>
<td>[0, 1]</td>
<td>[?]</td>
</tr>
<tr>
<td>( l )</td>
<td>Effectiveness of quarantine/isolation</td>
<td>[0, 1]</td>
<td>[?]</td>
</tr>
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\[ R_0(\sigma,l) = 1 \text{ boundary curves for } \beta = [0.15, 0.25, 0.40] \text{ to determine the critical vaccination coverage as a function of the quarantine/isolation effectiveness. As } \beta \text{ increases, the minimum } \sigma \text{ needed to control an outbreak increases.} \]

outbreak.

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References


