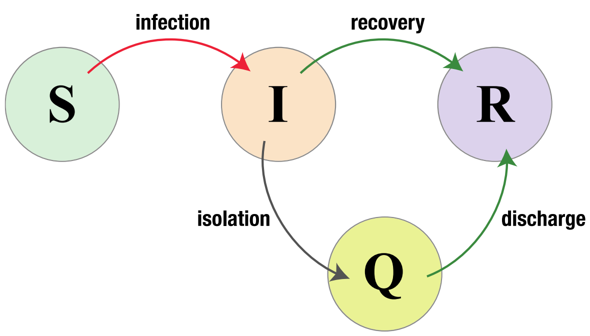
Poster-#(poster number, leave blank):

An SIR+Q Model with Limited Capacity of Isolation

Authors: Hiromi SENO, Ishfaq AHMAD
Presenter: Hiromi Seno seno@math.is.tohoku.ac.jp
Graduate School of Information Sciences, Tohoku University, Sendai, Japan

Isolation/quarantine is one of the proper strategies to suppress the spread of transmissible diseases in a community. In this work with the following mathematical model, we try to discuss how a limited isolation capacity could affect the final epidemic size defined as the total number of disease-experienced individuals at the end of an epidemic season with the spread of a transmissible disease. Our model is constructed from the classic SIR model with an additional class Q at which infective individuals are isolated without any contact to others.



$$\frac{dS}{dt} = -\beta \frac{I}{N-Q} S$$
$$\frac{dI}{dt} = \beta \frac{I}{N-Q} S - \rho I - \Phi(Q,I)$$
$$\frac{dQ}{dt} = \Phi(Q,I) - \alpha Q$$
$$\frac{dR}{dt} = \rho I + \alpha Q$$

with

$$\Phi(Q,I) = \begin{cases} \sigma I & \text{for } Q < Q_{\max} \\ \min[\sigma I, \alpha Q_{\max}] & \text{for } Q = Q_{\max} \end{cases}$$

and the initial condition $\big(S(0), I(0), Q(0), R(0)\big) = (S_0, I_0, 0, 0)$ where $I_0 > 0$ and $S_0 = N - I_0 > 0$ with a constant total population size N. Any demographic change due to birth, death or migration is assumed to be negligible in the epidemic season. Parameter β is the infection coefficient, ρ the natural recovery rate of the infective individual without isolation, and α the discharge rate of isolated individual after the recovery. The positive parameter $Q_{\max}$ means the capacity of isolation.

The piecewise function $\Phi(Q,I)$ denotes the isolation rate for the infected individual, which means that, when the isolated population size Q reaches the limit $Q_{\max}$, the isolation becomes feasible only for the room generated by the discharge of isolated individuals. As long as the recruitment of isolated individuals compensates the available room of isolation by the discharge, the isolation remains saturated. Only after the discharge comes to overcompensate the recruitment, the isolation works below the capacity and with a room for the recruitment.

In this presentation, we will show some principal results according to our mathematical model to imply the importance of isolation capacity enough to suppress the final epidemic size. If the isolation capacity is insufficient to cause its saturation in the epidemic season, the final epidemic size could become significantly large in comparison to the case where such a saturation does not occur. Further, unnecessarily long isolation period would contribute to the failure to suppress the final epidemic size to a successful extent.