Investigation of Nonlinear Epidemiological Models for Analyzing and Controlling the MERS Outbreak in Korea

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Highlights

- By fitting the SIQ model, which employs a squashing-type function for $\beta(\mathrm{t})$, to the real data on the confirmed cases and the quarantined cases, we obtained reasonable performance. Also, it turned out that the resultant estimated parameters belonged to plausible ranges. By comparison, the conventional SIQ model utilizing a constant transmission probability could not explain the observed data well.
- Our nonlinear epidemiological models showed that the MERS transmission probability decreased in the squashing-type fashion and then approached a saturation point in a time-dependent manner. As information on the MERS outbreak became widely known in the nation, efforts against this epidemic, including individuals hygienic behavior, and interventions by health care facilities and by authorities were accordingly strengthened. In our SIQ-based analysis, the inflection point for transmission probability was found to be $t_\beta = 21.8$, corresponding to a couple of days after 7 June 2015. Interestingly, 7 June 2015 was the day when the Korean government revealed the names of 24 MERS-affected hospitals to the public. After releasing the names of affected medical facilities, the rate of increase in new confirmed cases abated. As a practical guideline to avoid another similar unexpected outbreak, we draw the conclusion that combined efforts in the early stage are critically important, and sharing information including the names of affected hospitals or countries, clinical situations, and prevention methods might be important for global public health control.
- We applied optimal control theory to the controlled SIQ model with the goal of minimizing the infectious compartment population and the cost of implementing the quaranitne and isolation strategies. Simulation results show that the number of the MERS cases can be controlled reasonably well via the optimal control approach.