

A Probabilistic Model of an Infectious Disease, based on the BDI Process, and Maximum Likelihood Estimation of the Model Parameters¹

Hisashi Kobayashi²

Department of Electrical and Computer Engineering
The School of Engineering and Applied Sciences, Princeton University
Princeton NJ 08544, USA

Abstract:

A Markov process model of an infectious disease, based on a time-varying BDI (birth-and-death-with-immigration) process, is proposed. This probabilistic model can explain the unpredictable and often erratic behavior of an infectious disease better than the SIR model.

Next, we clarify, in a consistent manner, the relationships among the basic reproduction number, effective reproduction number, the exponential growth/decay parameter, the proportion of vaccinated population, vaccine effectiveness, and the behavioral factor of the public.

Finally, we discuss maximum-likelihood estimation of the model parameters, and present surprisingly simple formulas for estimating the parameters of our model, and the exponential growth/decay parameter.

References:

1. H. Kobayashi, "Stochastic Modeling of an Infectious Disease, Part I: Understand the Negative Binomial Distribution and Predict an Epidemic More Reliably." <https://arxiv.org/pdf/2006.01586.pdf>, June 2, 2020
2. H. Kobayashi, "A Stochastic Model of an Infectious Disease." A keynote presented ITC-32, September 22-24, 2020, Osaka, Japan. For slides and video, see <https://hp.hisashikobayashi.com/a-stochastic-model-of-an-infectious-disease/>
3. H. Kobayashi, "Stochastic Modeling of an Infectious Disease, Part III-B: Analysis of the Time-Nonhomogeneous BDI Process, and Simulation Experiments of both BD and BDI Processes," <https://arxiv.org/pdf/2104.00529.pdf>, March 30, 2021
4. H. Kobayashi, "Stochastic Modeling of an Infectious Disease, Part V: Maximum-Likelihood Estimation of the BDI (birth-and-death-with-immigration) Process Parameters," (in preparation) <https://hp.hisashikobayashi.com>

¹ To be presented at a joint study group conference "OR in Health Care" and "Dynamic Decision Models and Applications," The Operations Research Society of Japan, Sept 29, 2021

² The Sherman Fairchild University Professor of Electrical Engineering and Computer Science, Emeritus.
Email: Hisashi@Princeton.EDU, HP: <https://hp.hisashikobayashi.com>