Optimal intervention strategies for minimizing total incidence during an epidemic

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Abstract

This article considers the minimization of the total number of infected individuals over the course of an epidemic in which the rate of infectious contacts can be reduced by time-dependent nonpharmaceutical interventions. The societal and economic costs of interventions are taken into account using a linear budget constraint which imposes a trade-off between short-term heavy interventions and long-term light interventions. We search for an optimal intervention strategy in an infinite-dimensional space of controls containing multiple consecutive lockdowns, gradually imposed and lifted restrictions, and various heuristic controls based for example on tracking the effective reproduction number. Mathematical analysis shows that among all such strategies, the global optimum is achieved by a single constant-level lockdown of maximum possible magnitude. Numerical simulations highlight the need of careful timing of such interventions, and illustrate their benefits and disadvantages compared to strategies designed for minimizing peak prevalence. Rather counterintuitively, adding restrictions prior to the start of a well-planned intervention strategy may even increase the total incidence.

1   Introduction

The recent pandemic has underlined the need for non-pharmaceutical interventions to help mitigating disease burden in the society, along with vaccines and medications. Despite a solid body of past literature and an enormous research effort during the past two years on epidemic modelling, certain fundamental questions related to the optimal control of epidemics still remain open. In this article we discuss the optimal employment of non-pharmaceutical interventions to mitigate disease burden under the assumption that interventions incur societal costs which are accumulated over

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